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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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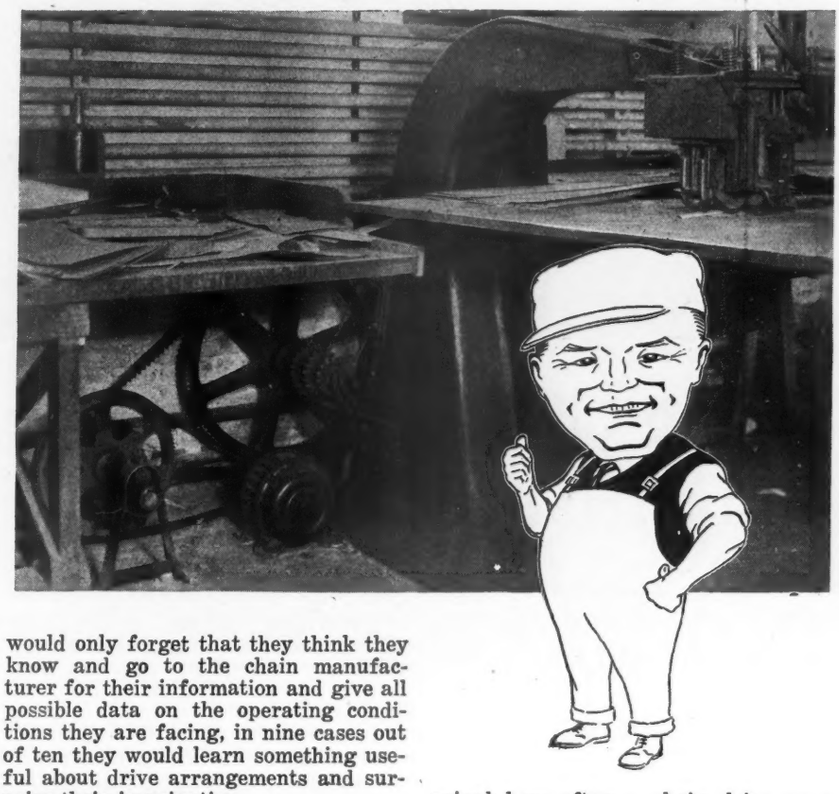
Are You a Bloodhound or a Setter

when working out new operating problems that appear to be what they are not?



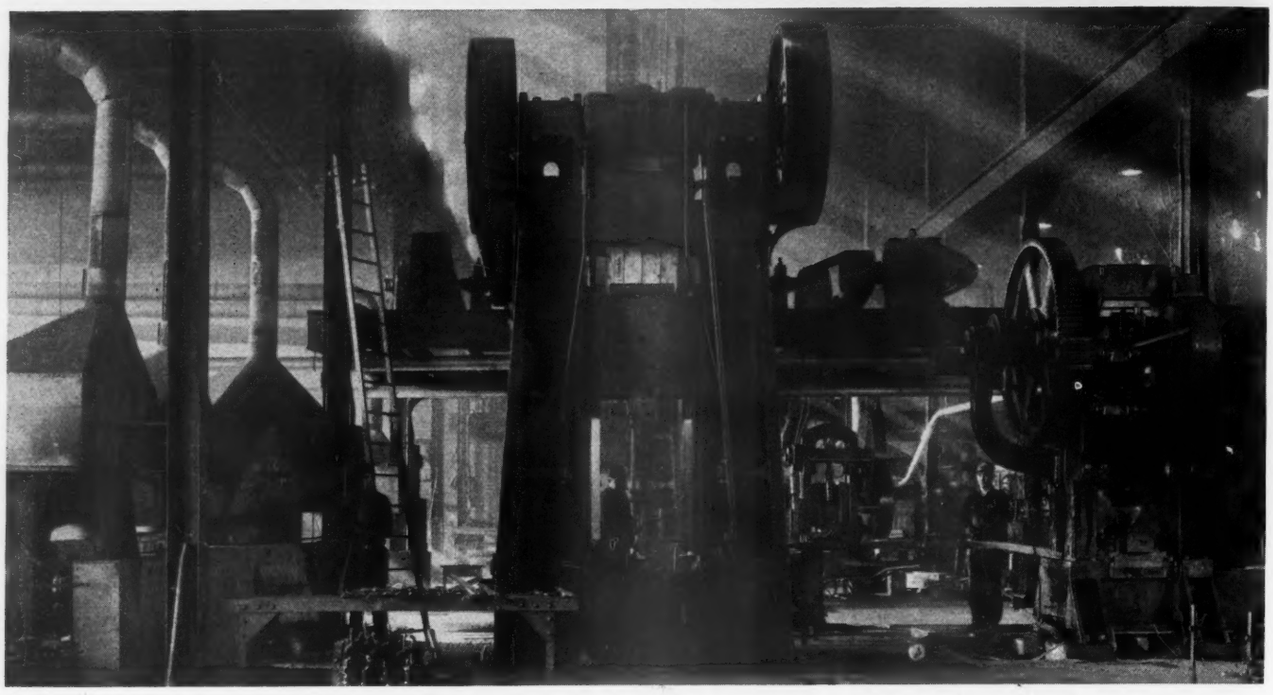
HERE is a photograph of a motor drive that tells an interesting story. The problem first faced on this job was to furnish a machine speed so low as to seem unreasonable, without much expense and a complicated drive in a small space. How this slow speed of 40 r.p.m. was worked out with a standard 1,800 r.p.m. motor and two Morse silent chains is shown in this photograph. The chain connected to the motor reduces the motor speed of 1,800 r.p.m. to 267 r.p.m. and the second chain then reduces the jackshaft speed from 267 r.p.m to 40 r.p.m., giving just what was desired, with a speed reduction that has high efficiency and gives no trouble. There might be other ways of doing the job, but this one shows how a plant man used his head and saved himself a lot of trouble in hooking up this special machine.

While on the subject of chain drives I want to give vent to some ideas of my own that you may or may not know, and may or may not agree with. We will not try to argue but just mention some facts. Every now and then you probably hear some wild statements about not being able to use a chain drive because of the noise it makes, or the limitations in the speed at which the chain must run. It is true that you can't run a chain at all the speeds of some direct connections of motor to machine, but in almost every case it is possible to use a chain drive without exceeding its speed limit of around 1,600 ft. per min. The trouble is that most men do not know how to figure the proper chain pitch and driving sprocket for a chain drive, and if they would only forget that they think they know and go to the chain manufacturer for their information and give all possible data on the operating conditions they are facing, in nine cases out of ten they would learn something useful about drive arrangements and surprise their imagination.

Now as to the matter of noise, if a chain drive is noisy it's not the fault of the chain, but is strictly up to the man who thinks he knows what a chain will do, but doesn't, and places an order on this information. Overspeeding the chain is actually the cause of noise in most chain drives. Moreover, by underspeeding the chain quieter operation can be secured than by using a low value of chain speed in feet per minute. Again, if there are possible surges in the load on a chain, a larger pitch is advisable. Still again, if the number of teeth in the driven sprocket is high, this spells at once a larger pitch than would ordinarily be used. These are just statements of fact without proof, and I realize that, but proof can be furnished by any chain manufacturer and that's the best place I know of to go for the proof. All I want to do here is to call your attention to these matters and suggest that you do no guessing with a chain drive but get first-hand information from a reliable source, and you will be surprised how often a chain drive or a combination of chain drives will save you a headache in hooking up a motor in a tight place.

Some one has said that a good engineer must have the good points of a blood hound and none of the bad ones of a setter. So take this for what it's worth and when you are thinking about using a chain drive, or are having trouble with one, hit the trail of the chain manufacturers. Like all other manufacturers who have been making things for a long time, they have a lot of good information tucked away that you can get for the asking; but if you don't ask—well you will be just like the setter that just "sets" until the man with the gun comes up and finishes the job.

Practical Pete



An installation like this, which is in one of the shops of the Westinghouse Electric & Mfg. Co., presents several problems in lubrication. Here, in addition to heavy bearing pressures, shock loads and heavy, open gearing, the equipment must be operated under rather dusty conditions, all of which increase the difficulty of providing adequate lubrication.

Using Oils and Greases for Industrial Lubrication

with a discussion of what these materials are, how they are prepared, and considerations affecting their selection and application

By FRANK E. GOODING

Associate Editor, Industrial Engineer

A FAIR estimate of the amount of power lost or wasted in transmitting it mechanically would be approximately 10 per cent. Much of this loss is due to what is known as the friction load. A body started in motion will not continue to move indefinitely unless the force applied is continued. The stopping resistance is known as friction and is always present when two surfaces have a sliding, rubbing, or rolling contact.

The amount of this friction load depends largely upon the character of the material in the shaft and bearing, upon the quality of the surfaces in contact, the pressure between the surfaces in contact, the speed of motion, and also upon various substances commonly known as lubricants which may be introduced between these surfaces. There are, then, five elements which influence the friction load: the character of the materials in contact, the quality of the surfaces in contact, the pressure, the speed, and the lubricant.

Industrial plant men are particularly interested in the problems involved in overcoming friction in the bearings of industrial equipment, although similar problems exist wherever any two surfaces slide, rub, or roll on each other. Take, for example, an extreme case such as trying to rub two rough bricks across each other. The rough surface of one catches in the surface of the other and so may cause a very high friction or resistance to motion, as well as considerable wear on the surfaces of the bricks.

If a bar of soap is rubbed over the surface of each of the two bricks until a thick coating is applied, which fills the rough surfaces, they may then be slid on each other with considerably less effort or resistance and practically no wear or abrasive action, at least until the soap is worn away and the surfaces of the bricks come in contact. In this case the soap acts as a lubricant, and this illustration is a typical example of the action of a lubricant. What actually happens here is that the resistance to motion is decreased by the lubricant (in this case the soap) and the lubricant (the soap) is worn out instead of the surfaces of the material.

A good lubricant is a substance which can be placed between two sliding, rolling or rubbing surfaces, to decrease the friction between them, and which will keep them from wearing. This point cannot be over-emphasized as upon a clear understanding of it depends the selection and use of a lubricant. Further, the example cited above is not so far from being related to industrial lubrication problems, because many grease lubricants are merely mixtures of soap and oil. Also, graphite serves as a lubricant in almost identically the same way, as will be explained later in this article.

No matter how smoothly metallic surfaces are finished, or how perfect the surfaces may appear to be, there are always irregularities which hinder the motion of one on the other. Even though these irregularities are microscopic, they produce an abrasive action which in turn produces heat. This heat is

the evidence of the friction that is present in the bearing or whatever the moving surfaces may be.

The purpose of lubrication is to interpose between the two surfaces a fluid film of such a nature that the metallic surfaces may be kept apart, so as to substitute fluid friction for metallic friction. That is, the film of lubricant fills in these irregularities and forms a coating over them in the same way that the soap covered and "lubricated' the surfaces of the bricks.

The Source of Oil Lubricants and Their Application

Mineral oil, which is the most common source of industrial lubricants, has been known to the world for centuries, but little use has been made of it either industrially or otherwise until in comparatively recent years. Today, petroleum and its products are more widely used than any other natural resource with the exception of steel. Many of the appliances made of steel would be utterly useless without the lubricating qualities found in the petroleum products.

The original use of petroleum, that is, in comparatively recent times, was as a burning oil, commonly known as kerosene and widely used as an illuminant. Of course, this demand led to the distillation of crude petroleum for the express purpose of obtaining burning oils, and such oils were limited in their specifications to exclude the lighter, more volatile and also the more explosive products.

The lighter products termed gasoline, naphtha and benzine were considered as byproducts, and their use was very limited. This was also true of the heavy oils that were left after the distillation of the kerosene. The heavier products were used for greasing purposes until the advent of high-speed machinery in the development of which mineral oils played an important part.

This situation has now changed materially, due to the development of the internal-combustion engine and the automobile. The lighter petroleum products have now assumed a place of superiority over kerosene; in fact, production and refining of crude petroleum for gasoline has difficulty in keeping abreast of the demand for motor gasoline.

The heavier oils, formerly considered byproducts, are also becoming useful as fuel in the operation of oil and Diesel engines while the still heavier oils form the group of products known as lubricating oils.

Lubricating oils form a range of petroleum products from light spindle oil to very heavy steam cylinder oils. The origin of these oils is varied and they differ with the region from which they come. For example, the Appalachian field produces a high-grade, paraffin-base crude, free from objectionable sulphur and from asphalt. These oils, which come from New York, Pennsylvania, Virginia, Kentucky and Tennessee, are rich in paraffin wax.

Approximating these oils in quality are the crudes found in western Ohio and northwestern Indiana, which states produce paraffin base crudes with traces of asphalt and sulphur. When these impurities are removed the oils are similar to the Eastern crudes.

The mid-continent field, comprising Kansas, Oklahoma, Texas and portions of Louisiana produces a variety of mixed crudes ranging in composition from a nearly pure paraffin base to a naphthene base, and containing varying amounts and kinds of impurities. The gulf coast field and the California field are producers of naphthene base crudes which are generally higher in their content of impurities than those from the other fields.

The three classes of crudes are handled somewhat similarly but the yields of products are quite different. Paraffin-base crudes are usually distilled with every effort to avoid decomposition by heat and yield the bulk of the high-grade lubricants. Naphthene-base crudes, on the other hand, will yield a greater amount of products when cracked, while mixed-base crudes are usually refined by a combination of the two processes, cracking and non-cracking.

Blending of lubricants is very common. They may be blended for viscosity, color, and other qualities. They may also be compounded with other oils such as rapeseed and lard oil to gain some special characteristic. In order to meet specific gravity specifications, oils may be mixed in certain proportions. Again, high cold and pour tests may be reduced by mixing with oils of lower test.

Compounding with oils other than mineral oils is often resorted to for obtaining special qualities. Cylinder oil, for instance, compounded with 5 to 7 per cent of tallow oil, adheres to the metal surfaces and produces a greater lubricating effect than would mineral oil alone. Animal

One of the problems of lubrication in plants working on cast iron is to have bearings tight enough so that the fine iron dust in the atmosphere cannot get into the bearings and score the shafts.

In particular, the large amount of conveying equipment which is found in many modern factories, especially in the automobile industry, presents an interesting problem in lubricating as it is exposed to the iron dust in the air and cannot easily be protected.

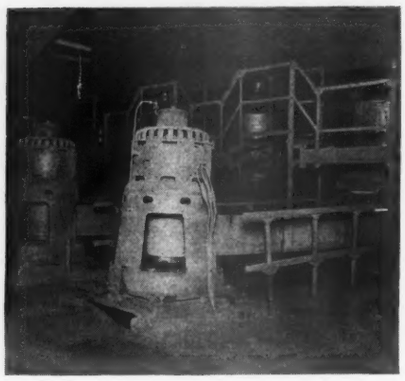
oils such as neatsfoot, lard, sperm and fish are used for compounding, as are also such vegetable oils as rape and castor.

One of the vegetable oils used as a lubricant is castor oil, which is made from the castor bean. This lubricant was much in demand during the World War for use on aeronautical engines. At present it is sometimes blended with other mineral oils to make lubricants for special purposes. Sometimes castor oil is used alone, although generally some mineral oil is added, when breaking in new bearings, because its stickiness is high. Extra-heavy mineral oils are also used for the same purpose. However, when pure castor oil is used for running-in a bearing and it is then desired to change to mineral oil, the bearings and the circulation system must be cleaned thoroughly because the castor oil forms a coating like varnish or shellac on the surfaces of the circulating lines. This coating is loosened by mineral oil and will clog the circulating system and interfere with the lubrication. For this reason, castor oil is seldom used alone, but generally has at least a small percentage of mineral oil in it to prevent the formation of this deposit.

According to the results of extensive tests by the government, castor oil is a heavy-bearing lubricant, and does good work for a while but may prove detrimental if used too long. It requires more frequent changing and renewing than do most other lubricants; also, it works better when hot, and therein is unlike mineral oil, which works best when cool. For this reason a different type of lubricating system is usually necessary for its use.

As stated before, castor oil has found favor with some operators for use when running-in-bearings on new equipment. Others find heavy mineral oil just as satisfactory. These opinions are usually based on the success or failure of experiments which may or may not have been carried on under the best operating conditions for the use of each kind of oil.

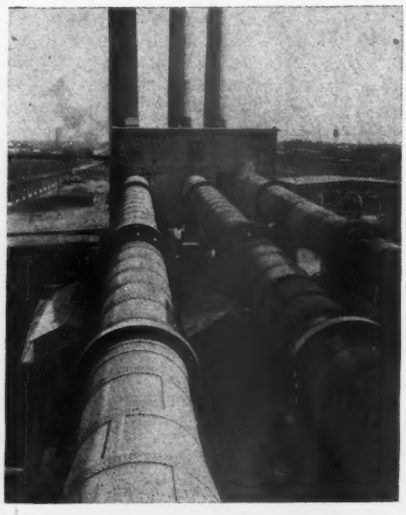
This difference of opinion calls attention to the necessity of having the proper conditions surrounding the use of any lubricant. Often, in the case of poor lubrication, the operating conditions, such as frequency of changing the oil, care in excluding dust or dirt, and the facilities for applying the oil to the bearings, are as much or more at fault than the lubricant used. Even the best lubricant for any certain condition may not give the best results unless it is applied properly.



Conditions such as shown here present one of the most serious lubrication problems in industry.
This shows the large vertical motors which are used to operate centrifugal types of pulverizers in cement mills. The equipment operates at high speed and the bearing pressures are likewise very high. In addition to this, the atmosphere is always laden with dust.

Why Blending and Compounding Are Problems of Manufacture

Blending and compounding of oils are the problems of the manufacturer and only he can hope, with his wide experience in handling petroleum products, to effect a combination of these that will be satisfactory and have the qualities required of a lubricating oil for a specific purpose. Without this wide experience and the accuracy that goes with the large manufacturing plant, all blending and compounding become a matter of pure guess work.



Bearing pressures are very high and the dust problem is serious in connection with the lubrication of kiln drives in cement plants.
In such cases the lubricant must have sufficient body so that it will not be crushed out from between the bearing surfaces by the high pressure.

For example, it is sometimes necessary to have a compounded oil for use where a bearing or other part is subjected to water. It is very essential that the oil used have the property of emulsification so that it can take up some of the water in the form of an emulsion and, combining with it, produce a tenacious film and yet retain its lubricating qualities. Such an oil can only be produced by a knowledge of the actions of various animal and vegetable oils in combination with mineral oils and in combination with each other. In addition, there is required a knowledge of the proper proportioning of the various oils and the proper time and temperature of mixing so that a permanent combination will be formed.

Again, it may be a low cold test oil that is required. In this case, it is necessary to blend certain oils to produce that characteristic.

Greases constitute simply another method of applying oil and are useful in those places where it is difficult or impracticable to apply an oil. Greases are plastic compounds of lubricating oils and soaps made from animal or vegetable fats. Most semi-solid greases are mixtures of mineral oils and saponified animal or vegetable fats, such as tallow, lard, or palm oil. They may also be of a pure mineral nature, such as petrolatum. Petrolatum, however, is not strictly a grease in the sense that it is produced by emulsion or saponification. Some of the viscous gear lubricants, however, come in this class, as they are pure petroleum products.

How Lubricating Greases Are Made and Used

Some greases are composed of pure animal or vegetable fats such as tallow, lard and other non-fluid products. These have certain uses of a more or less special nature and do not constitute the general run of greases for lubricating purposes. Mixtures of pure, fixed oil fats and pure mineral greases, such as petrolatum, comprise another easily-definable group of products.

The common greases that are met with in everyday problems, such as cup, sponge and railroad greases, are mixtures of soaps and mineral oil. These are commonly known as "hot and cold set" greases, the cup and sponge greases being produced by the "hot set" process, while the

railroad greases and axle greases are cold mixed.

Cup greases are usually made from what is termed a "lime soap base," having a content of 10 to 20 per cent fatty oil and sufficient mineral oil to bring the grease to the consistency required for the work. These greases are designated by numbers ranging from 0 or 00 to 6, with each number denoting an increasing degree of "hardness". The softer the grease, the greater the mineral oil content, as a general rule.

"Soda soap" greases are more difficult to make than cup greases and are called sponge greases. They may easily be recognized from the texture, which is fibrous and stringy, due to the process of manufacture.

Axle greases and similar hard greases are usually cold set greases and are made by mixing mineral oil, rosin oil and lime. Some greases contain fillers such as asbestos, talc, and soapstone, which really have no lubricating value. Only in rare instances where special characteristics are required is the use of these fillers justified.

It is obvious that, since a grease is made by adding a soap or similar material to a mineral oil, the quality of the product depends largely upon the quality of the materials used. For example, the fats added should be pure and sweet, instead of rancid and gummy. Where rancid fats are used, in the manufacture of a grease some scented material is usually added to cover up the rancid odor. Other factors in the manufacture of a grease over which the user seldom has any control are the necessity of proper cooking, mixing and proportioning of the different substances and the use of materials free from acids or impurities. These factors can be checked up by careful tests, but the average user does not wish to go to all of this trouble. For this reason it is advisable for him to make a careful investigation of each grade of product when first purchasing a lubricant and then trust to the reliability of the manufacturer, with perhaps occasional tests to see that the proper standard is maintained. However, more information on the testing of lubricants will be given in a later article.

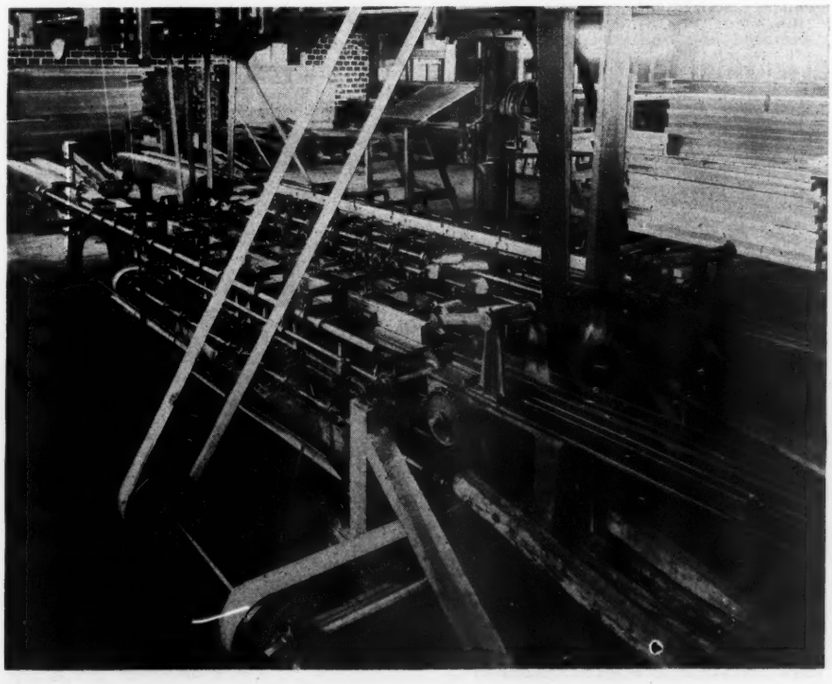
One of the main reasons for using a grease in many cases instead of an oil is that the oil would run off the surface while the grease will stick until it is worked into the minute openings in the surface of the bearing. This is particularly true of heavy bearings and also of gear teeth. Until within the past few years grease has been generally considered as the only lubricant usable on heavy gears and bearings. Many of these bearing surfaces are not suited to retain any other lubricant.

Present lubrication practices, however, are tending very largely toward totally enclosing many of these bearings, and also gears, with the use of an oil circulating and cooling system whereby clean, cooled oil is circulated around through the bearings or the teeth of the gears. Frequently enclosed gears dip into a bath of oil. These improvements in lubrication practices have resulted in the very economical use of lubricants. Also they have increased the life of gears and bearings because these are always positively lubricated, while dust and foreign material are excluded from the lubricant, which is a big step in eliminating wear. Some of the methods of applying the various lubricants under different service conditions will also be discussed in a later article.

Uses of Graphite in Connection with Lubrication

There is still another substance, graphite, which is quite frequently used in connection with other material for lubricating the bearings of industrial equipment. Graphite is a form of pure carbon; charcoal and diamonds are other forms of pure carbon. The so-called lead in lead pencils is usually graphite. It also has some electrical uses. Graphite is mined and in its natural state contains a number of impurities. There are two forms of graphite, flake and amorphous. The flake graphite is the form most commonly used for lubrication and is so called because it is found naturally in the form of flakes, somewhat on the order of mica. Because graphite as found in its natural state contains impurities much care must be exercised in its manufacture to remove them. The graphite is first ground fine, which still leaves it in minute flakes. One method of preparation involves flotation of the finely ground graphite in air or liquid where the impurities are separated out because of the difference in the specific gravity of the impurities and of the graphite. By special methods, graphite of almost 100 per cent purity can be obtained.

A simple method of testing graphite for impurities in it which would affect the bearing is to take some of the graphite and place it on a piece of glass. If the graphite is rubbed down and smoothed out with a thin-bladed knife, the scratching



Complicated machines in industrial plant oftentimes present difficult problems in lubrication.

The large number of bearings and gears on this woodworking machine must be lubricated even though the woodworking industry creates considerable dust which settles in the lubricant and plays havoc with open bearings. Also, such equipment usually operates at a comparatively high speed. In addition, in this installation there are several chains as well as bearings to be lubricated.

of any solid impurities can be heard. They will actually scratch the glass also. From this it can be seen that unless a graphite free from solid impurities is used in a lubricant the effect on a bearing will be much the same as putting emery dust in it.

Although the flake graphite is a lubricant in itself, it is not generally used alone but usually in connection with an oil or a grease. Many manufacturers can furnish various grades of oil or greases with the graphite already mixed in them. It is usually more difficult to mix a graphite with a grease than with an oil because of the difficulty of getting a proper mixture. This is largely because it is generally not advisable for a user to melt a grease lubricant so that the graphite can be more thoroughly mixed, because he is not familiar with the critical temperature and the care necessary in handling a grease at the melting temperature. Some greases would be spoiled by bringing them up to the melting temperature or at least would not be the same quality of grease when again solidified.

How Graphite Lubricants Act on Scored Bearings

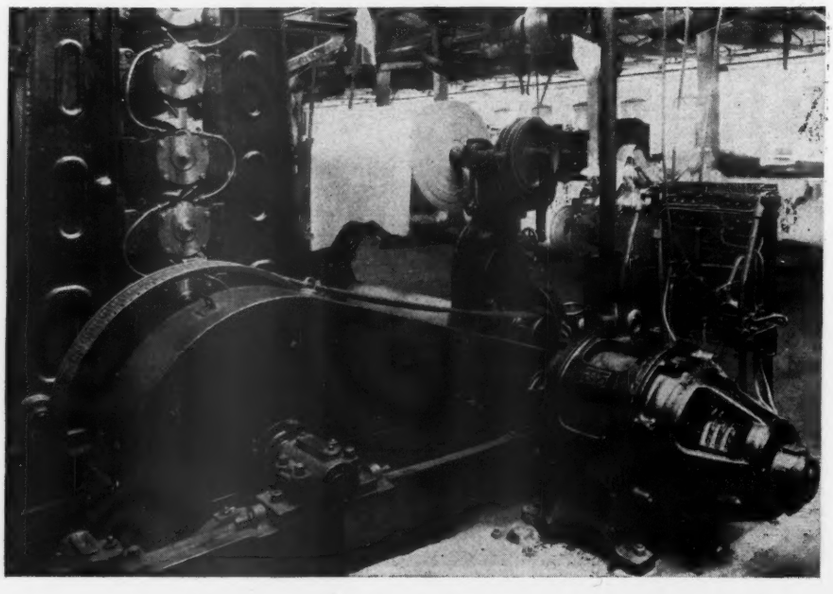
As stated before, even the most highly polished bearings in industrial equipment are not entirely smooth, as is shown by the microscope. The function of the graphite lubricant is to fill up the fine and even coarse openings or rough spots and so make a much smoother bearing surface so that it is more easily lubricated. For this reason graphite is very commonly used on scored bearings and also when running in a new bearing. It is not generally advisable to use graphite when oil grooves are cut in the bearings as the graphite will soon fill them up. If graphite is used during the running-in period the grooves should be thoroughly cleaned out before the bearing is put on a strictly oil or grease lubrication basis. Graphite is sometimes put in with the lubricant where a bearing starts to run warm and it is absolutely necessary to maintain the machine in service. This is common practice among engineers where a shutdown would mean stopping the entire plant. Practically any old-time engineer can "coax" a hot bearing with graphite until closing down time. In this case, also, the bearings should be cleaned out at the first opportunity.

Where there is a high bearing pressure, graphite serves still another purpose. In some cases the lubricating oil or grease would be forced out from between the bearing and the shaft by the high pressure, as, for example, in heavy roll bearings, large gears, particularly with cast teeth, and in other similar duties.

Under these conditions, the addition of graphite to the lubricant gives the lubricant a body which separates the shaft and bearing so that the oil or grease is not forced out entirely. Many of the heavy gear greases contain graphite which is used to fill up any inequality in the surfaces and also to form a coating on the teeth or bearings and shaft which takes the pressure and lubricates the surfaces in exactly the same way as would soap used on the surfaces of the two bricks mentioned previously. The graphite forms a slippery surface, fills in the inequalities in the surface and wears out instead of the metal wearing. An oil or a grease serves exactly the same purpose, although this function may not be as easily understood because oils and greases do not have the body that graphite does.

Because graphite will stand high temperatures it is very commonly used in connection with the lubrication of conveyors in ovens, kilns and other places where the heat quickly destroys all other lubricants. In such cases it is generally mixed with some form of grease so that it can be more easily applied to the gears or surface in contact. Because graphite is an electrical conductor it is not generally advisable to use it, except sparingly in emergencies, around electrical equipment.

Paper mills offer a difficult problem due to the high bearing pressures and the hot, wet atmosphere. In such cases it is not at all uncommon to use forced-circulation lubricating systems in which the oil is circulated through the bearings, cooled, filtered and returned for reuse. In addition, in this installation, the chain drive is totally enclosed and operates in a bath of oil which not only protects but lubricates the chains.



Some Suggestions on the Use of Oils and Greases

Fluid friction is naturally less than metallic sliding friction and is productive of little heat. The heat produced by friction within the lubricant, called fluid friction, is a measure of the suitability of the oil for the job. A bearing, for instance, may run excessively warm because of a too-heavy oil which causes an "oil drag". The oil drag may be so pronounced that it may be mistaken for bearing trouble of a mechanical nature, but in reality it is nothing more than the friction within the oil itself.

Oil that is of the correct body to meet the conditions of service will develop little friction and a well-designed bearing lubricated with the correct oil should develop little rise above room temperature.

Bearings are commonly lined with a composition metal such as babbitt, or they may be bronze-bushed. These linings and bushings are used with the idea of reducing the friction in the bearing. It is well known that "anti-friction" metals have a tendency to reduce the frictional resistance to motion. Steel on cast iron, or on bronze, or on babbitt metal will produce less friction than

steel on steel. However, under conditions of good lubrication when a complete film of oil is present, the nature of the metals makes little difference as far as the frictional resistance is concerned. The oil, by maintaining a film between the shaft and the bearing surface, keeps the rubbing surfaces apart and floating on an oil film.

Grease used as a lubricant has not the free flowing qualities that an oil has. The soap or sponge acts as a carrier for the oil, but remains also to partially nullify the effect of the oil. It is, therefore, obvious that many grease-lubricated bearings will run slightly warmer than if lubricated with an oil, due to the greater internal friction of the lubricant. In some bearings the clearances are so small that it is impossible to use anything but a very fluid oil. Such bearings are usually of the high-speed type and, therefore, the losses in frictional resistance must be kept as near to a minimum as possible.

Effect of Speed on the Choice of a Lubricant

In large, slow-speed bearings, the clearances are large and the opportunity of using a heavy oil or a grease is excellent. The frictional losses in the lubricant, due to the slow speed will be small in comparison to the power delivered. On slow-speed shafts, frictional losses are a minor consideration, the maintenance of the complete lubricating film to withstand the heavy pressures usually encountered in slow-speed shafts being the essential requirement.

The speed of the rotating shaft has a very important effect on the lubricant to be used. For example, in the small, high-speed shaft, a light oil is primarily necessary for the small clearances. It is also necessary because, due to the high speed, only a quick-acting oil will form and maintain a constant film and a complete film that a heavy oil cannot form and maintain at the high speed of the shaft.

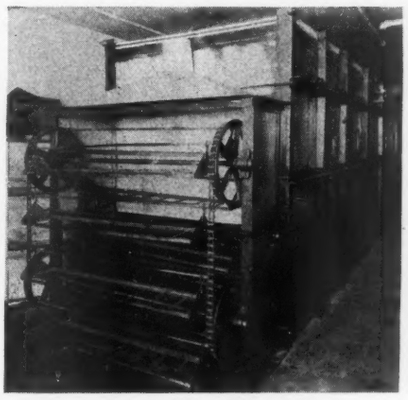
The heavy, slow-speed journal must have a heavier oil that will not run out at the bearing ends nor be squeezed out under the pressure of the shaft. It must also maintain the film under the conditions of slow speed, which are not so conducive to the maintenance of an oil film as are high-speed conditions.

Friction of lubricated surfaces, therefore, is not so much a theoretical problem of surfaces and speeds applying the lubricant is modern and reliable in its operation, friction of working surfaces becomes only a matter of fluid friction, which is best taken care of by the application of common-sense principles in the selection of lubricants. Oils can be so selected that they will eliminate metallic friction completely and with it, wear, abrasion and heating, substituting for it an easily supplied fluid, thereby reducing friction to a minimum and reducing power losses due to friction and much of the bearing trouble to a negligible quantity.

A discussion of the viscosity and other characteristics of lubricants, together with practical methods of testing them will be taken up in another article to appear in an early issue.

as it is a consideration of the practical features of the best obtainable lubricants, as well as the conditions under which they are to operate. That is, the oil or grease should be of the proper viscosity to serve the purpose at the operating temperature to which it will be subjected.

Assuming that the method of



Conveyors in ovens, kilns and other equipment operating at high temperatures offer a particularly difficult problem in that the lubricant is melted off under ordinary operating conditions.

For operating in high temperatures, graphite is frequently used, sometimes in connection with a grease. The grease is used to distribute the graphite and burns out from the heat.

EDITORS' NOTE: Special acknowledgment is made to the Vacuum Oil Co., New York City, for valuable information and assistance in the preparation of this article. Other companies who have co-operated are: Dearborn Chemical Co., Chicago, Ill.; Jos. Dixon Crucible Co., Jersey City, N. J.; The Pennzoil Co., Oil City, Pa.; Standard Oil Co. of Ind., Chicago, Ill.; Superior Flake Graphite Co., Chicago, Ill.; The Texas Co., New York City; Waverly Oil Works Co., Pittsburgh, Pa.

One Way to Install Tanks to Prevent Bottom Rusting Out

PROPER installation of steel tanks, of which practically every industrial plant has several, has much to do with their life. I found a good example of this several years ago and, as a result, now install all tanks in a way which prevents their bottoms rusting out.

While dismantling an industrial plant, I removed a number of circular steel bins that had rested on a concrete platform. The concrete projected beyond the sides of the tanks, and so permitted rain to run in between the tank bottom and the concrete. The bottom plates were so badly rusted that the tanks had no salvage value, and could have been used only a short time longer. As a result, whenever possible, I keep the concrete back from the sides of any bins and tanks that I install; that is, I allow the tank to overhang the concrete by an inch or two. When painting, thick paint is applied to the bottom edge of the tank in such manner as to form a "drip" which prevents the rain creeping under the tank bottom. A number of tanks thus installed have given very satisfactory service.

Bins and tanks are set on foundations that vary from earth to elaborate structures. Earth foundations are liable to wash out and the consequent local settlement may break pipe connections. Covering the area with crushed stone, well rammed, makes a better foundation. A foundation that combines effectiveness with good appearance, and one that has given the best of satisfaction, is made of a thin circular wall or ring of concrete, if the tank is circular, which allows the tank to overhang as described previously. The inside of this wall is filled with earth covered with fine stone or sand, which supports the load in the center.

The wall need not be reinforced unless it is desired to avoid shrinkage cracks. If the foundation is large, the circular form for casting the concrete may be made from thin lumber. Narrow boards, not necessarily tongue-and-groove flooring may be nailed to girts sawed in circular form, which gives the concrete the desired shape. A foundation need not be constructed exactly round; the boards give it the shape of a many-sided polygon, which is satisfactory. C. O. SANDSTROM.

Los Angeles, Calif.

With this graphic meter set up, tests are made of the overload relays, the accelerating relays, and a chart taken of the load cycle. This data recorded on the graphic meter chart makes a worth while performance record of the motor and control.

How a coke plant is

Using a Graphic Meter for Setting Overload Relays

and accelerating relays on controllers for motors, together with typical graphic charts and an explanation of how to interpret the results obtained

By G. A. SHARLAND
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THE importance of continuous operation and low operating costs of electrical installations in industrial plants is a matter that is every year receiving greater attention by operating executives. High-grade equipment is purchased that will invariably fulfill the conditions for which it is specified, provided that it is correctly adjusted and receives skilled attention.

The protection of electrical machinery has been gradually developed from the exposed link fuses that were dangerous and unreliable to the accurate and perfectly safe circuit breakers and overload relays of the present day. However, for the overload relays and the circuit breakers to perform their function they must be adjusted to trip at currents that are hazardous to the equipment protected. While the current at which an instantaneous trip circuit breaker or overload relay will open, cannot be accurately determined by means of an indicating or graphic ammeter, an ammeter, and especially a graphic instrument, will enable one to set a breaker sufficiently closely to insure that the motor and driven machinery will be adequately protected. The advantage obtained through the use of the graphic meter lies in the fact that a visual record is obtained of the load conditions during the test and if the current is slowly brought to a maximum, an accurate record of the tripping point is obtained.

In testing to insure that the protective equipment is properly adjusted, there are four factors to be considered. These are:

(1) The setting of a circuit breaker or overload relay to protect against short-circuits or instantaneous overload.

(2) The adjustment of the time-limit devices on overload relays and circuit breakers so that momentary overloads can be taken care of.

(3) The setting of current-limit accelerating relays on magnetic controllers to give proper protection during acceleration, so that the time of acceleration will be the minimum consistent with low starting current.

(4) The protection of induction motors against overload and single-phase operation.

Let us first consider the adjustment of the instantaneous trip and time-limit trip on overload relays and circuit breakers as mentioned in Cases 1 and 2 in the foregoing. A case in point is the Electric Controller & Mfg. Co. crane protective switchboard giving overload protection to the motor on a coal-charging car. The motor on this car is a General Electric type MD-104½, direct-current, series-wound motor rated at 35 hp., 220 volts, and a full-load current of 173 amp.

On this crane switchboard are two overload relays, one having a range of 150 to 300 amp., and provided with an inverse time-limit trip and the other having an instantaneous trip with a current range of 200 to 400 amp. The function of the inverse time-limit overload relay is to protect the motor against sustained overloads of more than 25 per cent in excess of its rated load, while the purpose of the instantaneous overload relay is to protect the motor and driven equipment against sudden and severe overloads such as might be occasioned by putting the motor on full line voltage with all the starting resistance cut out.

It was decided that for proper protection of the motor, the instantaneous overload relay should be set to trip at twice the full-load motor

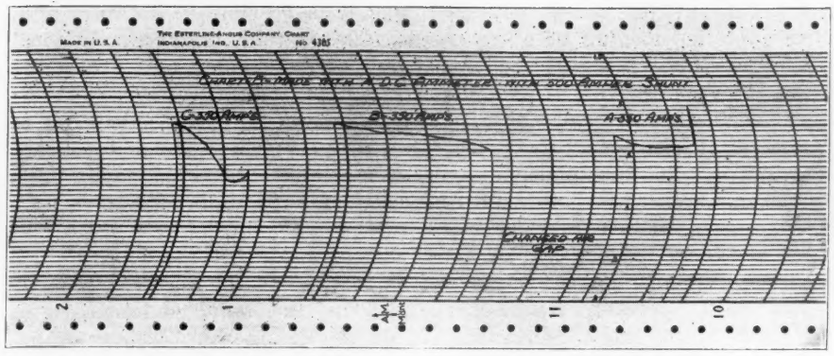


Fig. 1—Graphic ammeter chart taken during testing of trips on instantaneous overload relays.

current or 350 amp., and that the time-limit overload relay should be set to trip at 30 per cent overload, or 235 amp., in 25 seconds.

In resetting each relay, the operating coil of the relay was connected in series with a 500-amp. ammeter shunt and a water rheostat, all of which were connected across the 220-volt, direct-current power supply. By moving the plates of the water rheostat closer together or farther apart, the resistance could be changed and the current varied to meet the required value. An Esterline-Angus graphic ammeter was connected to the shunt so as to obtain a graphic record of what was taking place.

The setting of the instantaneous relay was determined by gradually raising the current, the plates of the rheostat being slowly brought together. Time was not taken into consideration in determining the tripping point on this relay. The air gap in the magnetic circuit was then adjusted until the correct tripping value was obtained. Four tests, shown on the chart in Fig. 1, were made. The results were:

Curve	Tripping Current	Remarks
A	330	As received from manufacturer.
B	330	Changed adjustment of air gap.
C	350	
D	350	

In making the tests shown in Fig. 1, a value of current is applied to the relay which is below the tripping point; the current is then gradually increased as is shown by the curve, particularly in the case of curve *C* in Fig. 1, until the trip point is reached, when the graphic meter pointer goes to zero.

In setting the time-limit overload relay a number of preliminary tests were made to get as close as possible to the specified tripping current. Adjustment of the air gap of the relay was made to obtain the proper value of tripping current. After this was done the time taken to trip for a given current was taken by means of a stop watch. The water rheostat was then set to give the specified tripping value of current and this current was applied to the relay, time being taken on the stop watch to ascertain the length of time required to trip at this value of current. While it was recognized that the time could be obtained directly from the graphic meter chart, when set to travel at 12 in. per min., a stop watch was used as a check on the results. The time limit was adjusted by varying the size of the oil holes in the dash pot of the relay. Tests were made as shown in Fig. 2. The results obtained in these tests are as follows:

Curve	Tripping Current	Time	Remarks
A	228	28 Sec.	Setting as received from factory. Time limit changed.
B	282	14 Sec.	Time limit changed again.
C	270	12 Sec.	
D	240	27 Sec.	
E	240	25 Sec.	

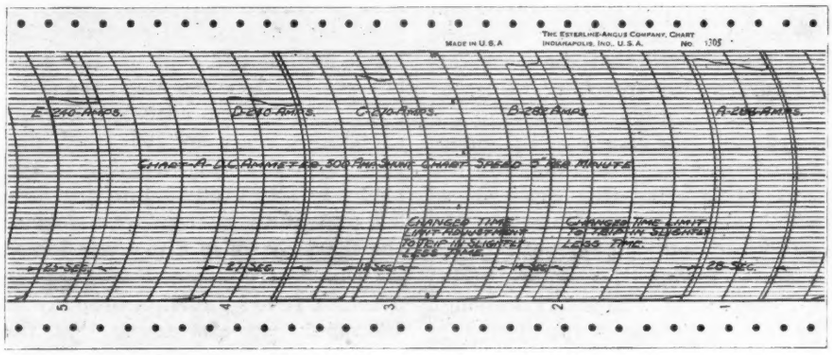


Fig. 2—This chart shows the tripping current and time required to trip on a test of a time-limit overload relay.

The setting of the time-limit overload relay was left as shown in curve *E* of Fig. 2, as it was thought that this was sufficiently close to give the motor suitable protection.

In the starting and acceleration of motors it is desirable that the change from partial to full voltage, that is, the cutting out of the starting resistance, should be at a rate that is consistent with the capacity of the motor. In other words, as mentioned in Case 3 in the foregoing, the accelerating relays on magnetic controllers should be set to bring the motor up to speed in the shortest possible time consistent with proper protection of the motor.

A typical example of this is a direct-current series motor driving

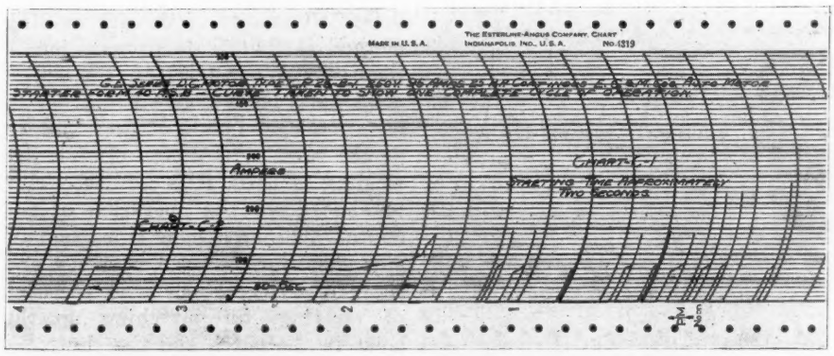


Fig. 3—Adjusting accelerating relays by the use of a graphic ammeter.

The first curves at the right show that a peak current of 250 amp. was reduced to 140 amp. as shown. by changing the adjustments of the acceleration relays.

an air compressor. This motor is controlled by an automatic magnetic controller that is caused to function by an automatic pressure regulator, which is set to start the motor at 40 lbs. per sq. in. of air pressure and stop it at 85 lb. per sq. in. pressure. As the equipment started and stopped about 300 times a day, it was desirable that the starting current be kept to the minimum value consistent with the motor being put on the line in the shortest possible time.

The motor used is a General Electric 25-hp., 250-volt, direct-current, series-wound motor. It is controlled by means of an Electric Controller & Mfg. Company form ASB magnetic starter. This starter has four accelerating relays which cut out successive steps of the accelerating resistance. A 500-amp. ammeter shunt and graphic ammeter were connected in series with the motor armature and the chart shown in Fig. 3 was taken. Full-load current on the motor is 95 amp., and from the chart it may be seen that the first test showed that the accelerating current was reaching values of 240 amp., or approximately 250 per cent of full-load current. By changing the current adjustment on the accelerating relay this was reduced to 140 amp., or approximately 150 per cent of full-load current. Under these conditions, the motor started in 2 sec. which is plenty fast enough for the conditions of operation that we have to contend with. Chart *C-1* in Fig. 3 shows the test made for determining the correct adjustment of the accelerating relays. Chart *C-2* in Fig. 3 is a high-speed chart and shows a complete cycle of operation which includes starting up, compressing air, and shutting down.

The setting of overload relays on polyphase induction motors is the same as on direct-current motors, both for the current and for the time-limit adjustment. However, one of the most frequent causes of the failure of polyphase induction motors is the opening of one wire to the motor. When this condition exists the motor will, if running, continue to operate single-phase and will take 173 per cent of the current that it would take under normal operation. With the overload relays adjusted to take care of overloads of 125 to 150 per cent of normal full-load current, the overload relays will prevent single-phase operation of the motors. However, it is essential that a check be made to insure that these overload relays are set sufficiently low to take care of this condition. A test was made on a 50-hp., 220-volt, three-phase motor which drives a centrifugal pump. This motor is controlled by a manually-operated compensator. Overload protection for the motor is provided by two General Electric Company Type P, Form C-46 overload relays. Full-load current of the motor is 117 amp. It was felt that 150 per cent of full-load current would be the proper tripping point for the overload relays. Inasmuch as 135 per cent of 117 amp. is approximately 160 amp., the overload relays were adjusted by the calibration plate to 160 amp., and then by connecting a graphic ammeter in the circuit by means of a 200-to-5 ratio current transformer the chart shown in Fig. 4 was taken. As can be seen from the chart the overload relays function properly at 160 amp. It was found that the time required to trip was 20 sec. This was thought to be too long, and was reduced to approximately 5 sec.

In conclusion it may be said that the successful operation of motors depends largely on the overload protection that they have and how accurately the overload relays are set. With the proper setting of relays it is possible to obtain a condition wherein one reduces to a minimum the number of shutdowns consistent with the maximum protection to equipment. Adjustment of relays is easily made by means of a graphic meter having a high chart speed; this procedure has the further advantage of giving a permanent record of the setting, both as to the current necessary to trip and the time required to act.

Fig. 4 — Testing the overload relays used with an induction motor to determine whether they will protect the motor against overloads and single-phase operation.

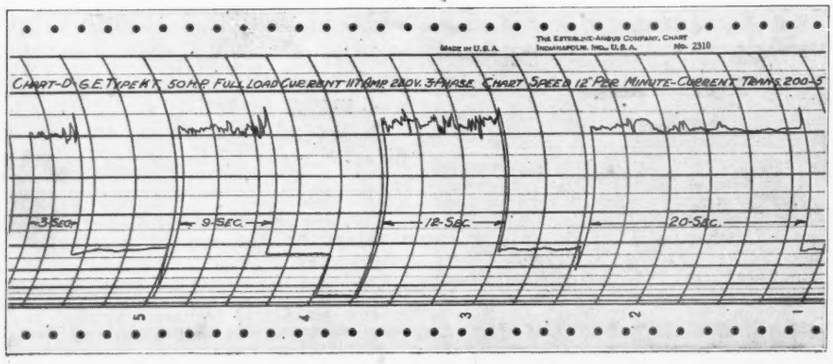


CHART-D G.E. TYPE M.T. 50 HP FULL LOAD CURRENT 117 AMP 220 V. 3 PHASE CHART SPEED 12" PER MINUTE-CURRENT TRANS. 200-5
3 SEC.
9 SEC.
12 SEC.
20 SEC.

Arc Welding Cuts Repair Cost in Cement Mill

AS BEING a typical instance of the large savings that can be made in plant repair work by the use of electric arc welding in place of riveting, for joining pieces of metal, the Lincoln Electric Company's research department at Cleveland, Ohio, has compiled figures covering certain features of such work in cement mills. Based on actual and numerous instances of repair work on dust chutes in cement mills, it was found that a patch welded by the electric arc costs in tangible expense only about one-thirtieth of what the same job would cost when done by the riveting method. The following comparison of the cost of a repair job which requires putting on a 4-in. by 4-in. patch, in a cement mill, shows typical costs of doing the work.

RIVETED METHOD

Two men required for 2 hr.

Operation	Cost
Drill holes	$1.20
Fit up	.60
Rivet	.60
Total	$2.40

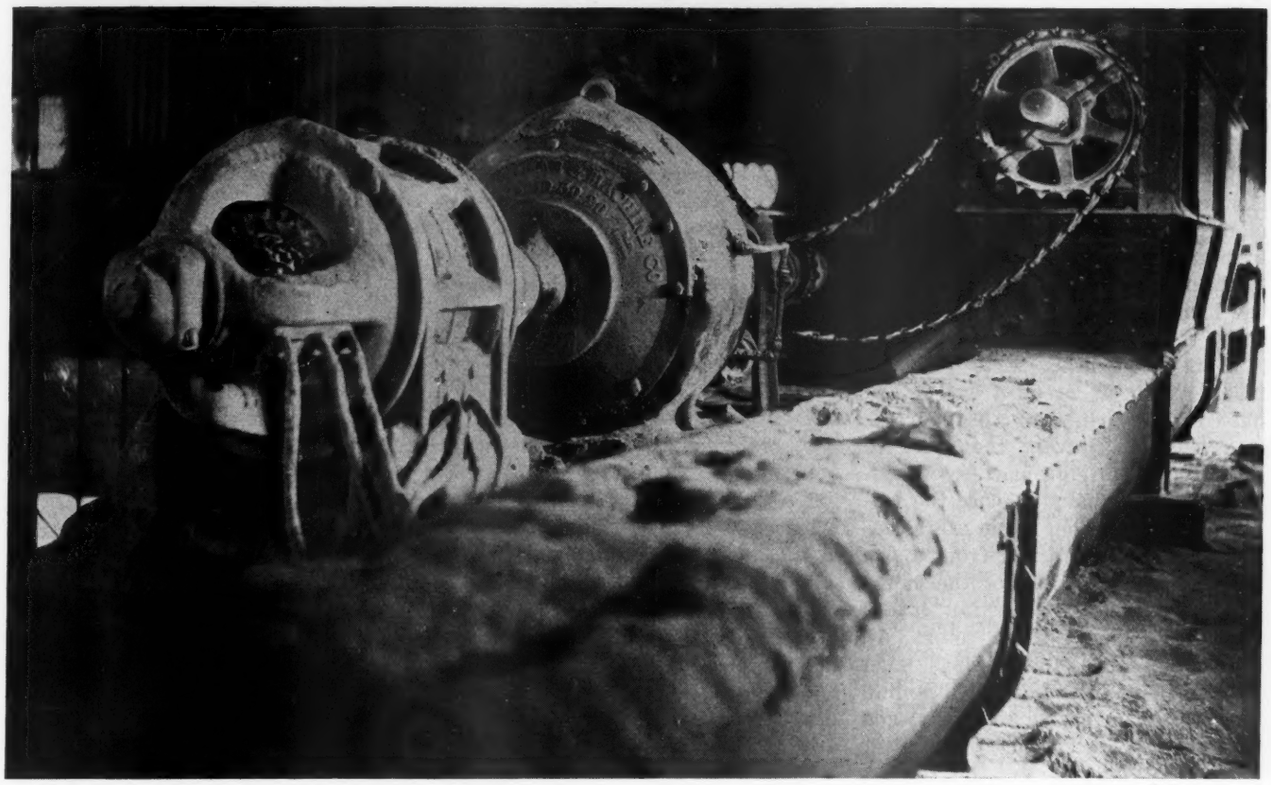
WELDED METHOD

One man required for 5 min.

Operation	Cost
Weld patch	$0.08

On this particular job where the riveting method was used, the cost included labor, power, and rivets. In the case of the welded job, labor, power, and welding wire are included.

One advantage of the arc welding method is that little preparation is required. When riveting, the equipment must be shut down in order to let a man get inside of the chute to do the riveting. Where electric arc welding is used, it is not necessary to shut down the operation of the chute. The job is done from the outside, no holes have to be made and there is no occasion, as in the case of riveting, for matching up the holes in the patch and the chute.



Dust is one of the big factors which affect the operation of plant equipment, as may be seen here. This direct motor drive through a Foote Bros. Gear & Machine Co., Chicago, Ill., speed reducer operates a trough screw conveyor in a cement mill.

Some of the

Maintenance Problems in the Small Plant

that have an important bearing on production, with suggestions on how they may be solved satisfactorily in the absence of a highly trained organization

By MAURICE C. COCKSHOTT
Engineering Department, Emsco Steel Products, Los Angeles, Calif.

ONE OF the difficulties incidental to the work of the maintenance organization in the small, and especially the isolated, mill or plant employing approximately 100 to 150 men, is that often the work must be done by less highly trained or specialized men than are found in the larger plants. The small plant obviously has less of this work to do and so can generally get along with less highly trained supervision and less skilled men to do the work. In consequence the work is more likely to be conducted in somewhat haphazard fashion. Further, proper facilities may be lacking for handling maintenance and repair work in an efficient manner.

These and other problems are discussed in this article, and suggestions given on ways of making the best of the circumstances which result from the conditions that are present in the small or isolated plant and cannot be wholly eliminated.

The department which requires the most attention from the maintenance workers is generally the power plant, where cleaning boilers, relining and repairing furnaces, and other similar duties occur periodically. This, however, is such a special subject and the problems so similar in all types of plants that it will not be discussed further here. It is well to keep in mind, however, that in the small plant this work is generally done by the general repair gang, while in larger plants the power department may have its own gang of men.

In mill and factory maintenance there are three types of equipment —motors, belts and bearings—common to practically all industries, which require a large proportion of the attention of the maintenance workers and the operating men. Continuous operation is largely dependent upon the reliability of all of these elements of the power drives. Attention given to any of these is usually amply repaid in more satisfactory operation with few interruptions.

In the plant proper the equipment which should receive the most careful attention is the motors. It is not true that the motors require the most maintenance and attention, but it is generally true that the amount of care and attention given to them affects the amount of actual maintenance and repair work which may be necessary. Inspection and care seldom interfere with production; breakdowns stop production until a repair or substitution can be made. For this reason, it is well to consider the following facts about industrial motors.

Except where heavy starting torque is required, as on fans, kilns and compressors, the squirrel-cage

motor is in general use in all industrial plants. In mills where service conditions are unusually hard, the rugged construction nables this type of motor to give very reliable service. Where motors are housed in as a protection against dust and wet they will not need much maintenance beyond blowing out with an air hose at regular intervals. With motors of the slip-ring type, the brushes require attention, especially if in a dusty location.

It is good practice to put the motor overhead, or on a well-raised base rather than near the floor, as this helps to prevent the entrance of chips and foreign matter. Whenever it is necessary to place the motor in a hot corner some air circulation may be obtained from a fan keyed on to the shaft, or the motor can be purchased with fan blades built in as a part of the rotor. All starters, controllers and relays, must be kept in as clean a part of the mill as possible, inspected regularly, and cleaned and lubricated. This latter should not be done by the regular oiler, but made part of the electrician's duties. It is well to take a little care in choosing the place of mounting such equipment as generally one side of a machine is cleaner than the others, due to the way the material is fed, or to the location of a window, or to other surroundings.

How to Get the Best Service From Belt Drives

Belt drives are another important and often much-neglected part of the power service equipment in the small plant. Frequently the policy of purchasing the cheapest belt obtainable is followed where belt life is short, due to the severe operating conditions. In such cases the cheapest belt will often last as long as another belt which may be higher in price, but no better suited to the conditions. Under conditions which are ideal, and in many cases where they are not, it is hard to beat the leather belt. Any type of belt should, of course, be installed to suit the particular type of drive which it serves and be maintained properly. On drives which have paper pulleys, the crown should be checked up from time to time. In an emergency, this crown can be built up temporarily by means of adhesive tape although there are other products on the market which are better and more lasting. All belt drives must be kept up to the tension that will give the maximum efficiency. Especial care needs to be given to new leather belts until they have become run in. It is not good policy to draw them too tight when installed, but rather to take up any stretch gradually.

Plants which have belts operating under severe conditions can usually find one or more special types of belts which are made by some method or of some material that is not affected by the service conditions. There are literally hundreds of these belts on the market which are designed to be used under some special conditions of heat, cold, wet, dry, abrasive dust, shock load, or any of the possible combinations of these which may be met in industry. It is well to study the claims of the manufacturers and the construction of these belts and then try out the belt which seems to be best, taking care in each case to follow the manufacturer's recommendations on method of installation, type of fastener to use, side to go next to pulley, crown, speed, and any other operating factors.

It should be remembered that because a belt solves one difficult operating problem, it does not necessarily mean that it will work as satisfactorily under other severe conditions. I have found that in hot and dusty surroundings a rubber belt, when properly applied, will give satisfactory service. Successful power transmission will depend, however, upon using a belt with the correct number of plies of material, and upon the use of pulleys of the proper diameter so that the belt operates at the right speed for the power to be transmitted. If these factors of speed, plies, and diameter of pulleys are not properly balanced, the frictional heat will break down the material and the life of the belt will be short. The manufacturer will give recommendations. Another advantage of rubber belting is that it is waterproof. This makes it usable also in hot and wet atmospheric conditions.

The belt fastener is of much more importance than is usually considered. There are many types of fasteners on the market and in most cases each of these types is made in various sizes for different weights of belts, diameters of pulleys, and so on. Often much of the trouble attributed to belts, and classed as belt failures, is due to the use of the wrong type or size of fastener, or to an incorrect application, such as, belt ends not square, joints not true, fasteners too near the end of belt, and so on. In choosing fasteners I have given preference to the hinged type of fastener with rawhide or Bakelite pins on belts up to 8 in. wide and of medium thickness. On larger sizes I use, generally, a fastener of the plate-and-rivet type

Proper lubrication is of prime importance in industries where dust is a factor.

On belt conveyor installations such as this, the pressure grease gun system of lubrication has many points in its favor. The pressure under which the grease is applied forces any foreign matter out of the bearings and fresh grease into them. This installation was made by the Stephens-Adamson Mfg. Co., Aurora, Ill.

In this case, a different type of belt overcame a troublesome condition.

This mule stand operates in a pulp mill in an atmosphere filled with condensed steam which keeps the belt dripping wet continously. Belts which absorb moisture either stretch or shrink and on one occasion another belt on this drive shrunk to such an extent as to break loose the drive shaft. This 5-ply, 10-in., extra-heavy rubber belt transmits 50 hp. at a speed of 1,500 f.p.m. and travels over pulleys 26 in. in diameter. These belts last from 14 to 16 mo. and do not shrink nor stretch. Previous belt installations averaged only a few months in service. This installation was made by The B. F. Goodrich Rubber Co., Akron, Ohio.

of the proper size to give sufficient space between the end of the belt and the rivet so as to decrease the likelihood of the fastener pulling out when the belt begins to age.

Mill Bearings and Their Lubrication

Because bearings and their lubrication are mentioned third in the above list of the three most important types of equipment which require the attention of the maintenance and operating departments does not indicate that they are third in relative importance; generally a failure in any of the three elements affects more than merely the unit which has failed.

Bearings have to withstand considerable hard usage in a mill, especially when subjected to abrasive dust in the air. Also, they are often placed in out-of-the-way corners where their lubrication is neglected. A trip through many mills would disclose places where a grease cup was probably installed when the bearing was put in, but it is now operating with no provision for lubrication because the cup came off and has not been replaced. All bearings should be looked over at regular intervals, cleaned and taken up where needed. On a bearing operating at comparatively high speed I favor the pin-cup type of lubricator, which is merely a cup with a copper wire soldered on to the cap and allowed to trail on the shaft. The heat caused by the friction of the wire on the shaft melts a little of the grease and allows it to form a film around the bearing. The use of any grease which may be on hand will not give the best results unless the grease is meant for that type of bearing. It is particularly advisable to obtain the proper pin cup grease for use with a pin-cup type of lubricator.

The Use of the Pressure System in Mill Lubrication

Probably one of the best methods of lubricating the general run of mill bearings is by the grease gun pressure system. Sufficient power may be applied with the gun to force the grease into the bearings and on through to form a collar of grease around the outside that will prevent the entrance of dust and abrasive substances between the shaft and the babbitt or other bearing metal. One of the common mistakes made in connection with the use of a grease gun is to use it too infrequently.

In the case of ring-oiling pillow blocks or bearings, care must be taken to see that the rings are revolving with the shaft and also that the oil is changed periodically. A pocket flashlight can be used to inspect the rings in the bearings to see if they are turning. On some types of mill machinery a saving can be effected by using the oil drawn off from the crankcases of trucks and automobiles; it is, however, best first to strain it through a flannel bag to catch bits of metal and so on. The small amount of gasoline that is present will do no harm as it thins out the heavy oil. Bearings, so lubricated, however, need to be watched very carefully. It is not advisable to use this oil on motors, special machinery, reduction gears, or on equipment where the manufacturer specifies a particular grade of oil. In such cases, it is often poor economy to depart from the specifications, as the maker of the machinery has usually experimented until he can recommend the lubricant that gives the best results.

With the heavy machinery around the mill, such as kiln gears, crushers and so on, there is often a tendency to apply a too generous supply of oil or grease; this results in an untidy and dirty machine and often a slippery and hazardous floor. To prevent this the oiler should be instructed as to the quantity of oil to use, particularly so in the case of bearings with an overflow. I have tried the plan of giving an oiler a definite quantity of lubricant, which was considered sufficient for his shift, and telling him that there would be no more forthcoming; he usually ends up by having some left over. However, there is danger of his neglecting bearings occasionally. If he is an old employee and has been on this work for some time this plan can be tried out and will most likely work satisfactorily.

With heavy gears and pinions, a grease that has to be warmed up and applied with a brush once or twice a day is an economical lubricant to use, as it does not collect so much dirt and carry it around with the gears.

In addition to motors, belts, and bearings each industry or mill has certain types of machines which require considerable attention. This article will discuss the maintenance and operation problems in connection with various pieces of equipment.

Bucket elevators, for example, are found in a wide variety of industries and are a type of machine that requires close care and maintenance. In fact, many engineers are prejudiced against bucket elevators because their maintenance cost is high. This high cost, however, is

generally due to allowing the elevators to run as long as they will without attention. Experience has shown that in a mill where space is an important consideration, the bucket elevator, if properly cared for, is no more expensive to maintain than any other machine, if it is the right type of elevator for the work and is used properly.

The cost of improper use is well shown by the following example. In one mill, ore had to be elevated from a trommel screen to a feeder bin. An old, discarded, vertical bucket elevator was impressed into service. In order to get the heavy ore to discharge clear of the elevator head, the speed had to be increased far above that at which it was intended to operate. This resulted in a correspondingly increased wear and tear on all parts. Costs of the work done on this elevator, including the maintenance, were kept for the year and reached a total that would have gone far towards remodeling the arrangement and also towards installing an indirect continuous elevator that would have, with proper maintenance, given good service with a minimum of trouble. On this same installation, an extra bin was built in to be fed by this elevator. This also required the addition of a small conveyor on top of the bins in order that the ore could be distributed as required. All this could have been avoided by putting in the right type of equipment in the first place and having a bifurcated chute to each bin.

The installation shown at the bottom of page 572 was more expensive to install than was necessary. In this case two motors are used to drive a trommel screen and a small roll. However, one motor driving a jackshaft would do the work as well. Although group driving cannot always be advocated, there are conditions, as here, where it can be used to advantage, because on this installation if one piece of machinery happens to go down the other must be stopped.

The handling and storing of tools and supplies for the maintenance department is not always done effectively. Often there is no system at all; each man is supposed to have his own tools, and these are frequently in a much neglected condition. The first thing to do to improve this condition and put in some sort of system, is to collect all tools, good and bad, and place them on a tool account.

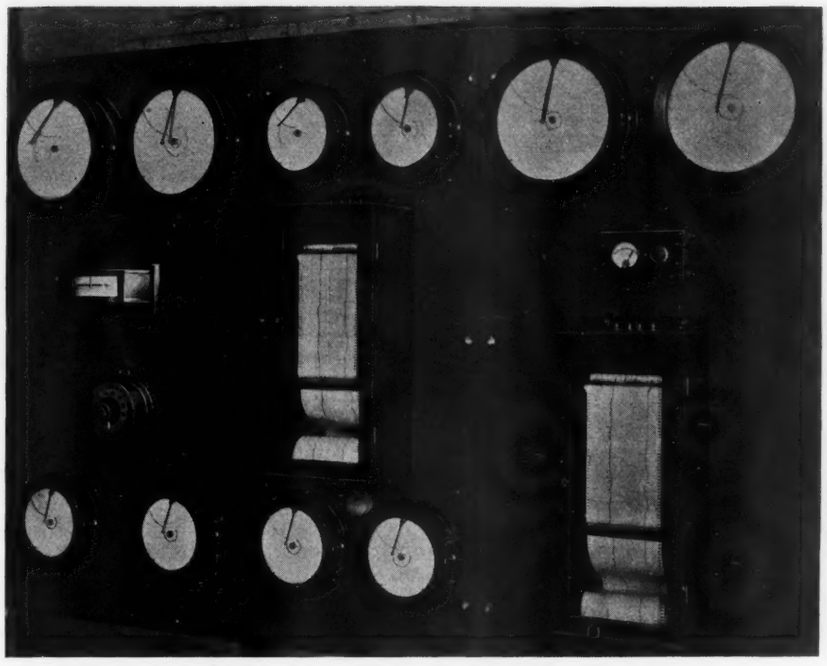
Problems in the Handling of Tools and Supplies

Plants which have a toolroom and stockroom for the production department can sometimes issue special tools and supplies from it to the maintenance department. However, some provision must be made so that the maintenance workers can get at their tools and supplies on Sundays, at night, or at any other time. Large maintenance organizations can keep their own toolrooms and supply stores. The small plant may find this too expensive.

A plan which the small organization can follow is to build tool and supply lockers at different places around the plant. For example, one locker might be placed in the machine or repair shop, others in various places in the mill at some distance from each other, and one or more outside for bars, shovels, and so on. Each of these should be stocked with the tools that are considered necessary in the various locations. In the mill, for example, this locker could contain a hammer, several chisels, three big wrenches and any of the special tools that may be needed for the particular equipment used. The machine shop will need a larger selection and the tools for the outside locker will have to be selected as may be needed. Keys to these lockers should be given only to certain men, who should be held responsible for seeing that the tools are in their proper places and that they are taken care of.

Before putting these tools in the lockers they should first be put in good shape by renewing handles, when necessary, putting new jaws in wrenches, and so on. Tools that have worn out beyond repair should go to the scrap heap, as nothing is more troublesome than for a man to find himself on a job, especially in an awkward place, where his wrenches will not grip or his chisel will not cut. Any extra or expensive tools, or other equipment,

Indicating and recording instruments can, if properly used, do much towards reducing the maintenance and operating costs of kilns and other equipment. These Brown indicating pyrometers are installed at the kilns of the Pennsylvania Cement Co., Nazareth, Pa.



A typical installation of instruments in one plant.

This installation of indicating and recording instruments indicates a convenient arrangement of meters which might be used to show the consumption, pressure or other operating conditions at various locations or departments. This installation was made by the Brown Instrument Co., Philadelphia, Pa. As explained in the accompanying article, it is not advisable to turn valuable instruments such as these over to anyone to take care of, as they can easily be put out of order. The danger of this is greatest in the small plant where there are only a few instruments to be looked after.

should be let out on a tool check or put under the direct charge of the foreman.

It is not necessary to put in an elaborate and complicated check system: this can be as simple as possible; all that is needed is to know who has the tool. In a small organization all that would be required is to have a place for every tool, either in a drawer, or hanging up, with a numbered tag on it. Numbered checks corresponding to his card or time clock number, should then be issued to each man, for which he signs a receipt; on drawing a tool out, his check is placed on the tool hook. This method shows at a glance what tools are out and to whom they have been issued. When a man quits, he must first get a tool clearance before he receives his pay. Replacements of broken tools should be made only when the man turns in the broken parts: lost tools should be replaced only on the authority of the foreman. The above outline is merely a guide, to be modified or enlarged as necessity or occasion demands.

Maintenance work on the building and yard also comes under the supervision of the maintenance department. Among other activities the woodwork, such as framing, bins and runways, and so on, should be given periodical coats of paint, or better still, be painted with a so-called fireproof paint. In many localities the insurance rate is materially affected by this precaution. Also, there should be sufficient fire hydrants to enable hose lines to be brought to any part of the plant. A supply of hand fire extinguishers should be provided, which must be inspected and refilled periodically. Fire-fighting apparatus must be systematically overhauled and disciplinary measures taken with anyone using fire hose for any but the proper purpose.

Pumps are another piece of equipment common to all industries which are often very much neglected as long as they function. The careful mechanic will see that all lost motion is taken up, the valves packed, and the pump kept clean and in good working condition at all times. One often wonders how the old reciprocating pump, that is usually tucked away in a corner, performs the work that it does, considering the little attention it gets. However, there is always a last straw that breaks the camel's back and when the almost forgotten pump is called upon for an emergency, it fails and all through the neglect of a little timely maintenance.

The writer has been around many small plants, where as long as the equipment keeps going, no one worries about maintenance, and where the sight of good machinery being ruined for want of attention is almost akin to criminal neglect. The need of the application of more modern maintenance practices is very apparent in some small mills. It would be well for some of the heads of these plants to follow the example of the big factories, where proper maintenance is one of the mainstays of the organization, instead of being inclined to sneer at the "new-fangled ideas," as is so often the case.

Many good ideas come from the man on the job and are worth looking into. One way to get these ideas is through the suggestion box, by offering a small reward for workable ideas. This is being used with good results by some of the most successful plants in the country.

How Charts and Records Help Operation and Maintenance

Control of maintenance, operation and production is probably best kept by a study of charted records of everything that goes on. This can be done only by having a complete record of the why and wherefore of every change in operation. Unfortunately, in many good mills no record is kept of the different factors that govern production, and no consideration is given to the importance of having a reliable check on these factors that really determine production and operation costs. Where pyrometers are in use it is often advisable to use recording equipment. The continuous record of operation that the charts give may show very plainly where saving in fuel or improvement in quality of the product may be made through accurate control of temperature, better scheduling or handling of work, and so on.

The value of electrical recording instruments, when intelligently used, speaks for itself, especially when power is being bought and such nightmares as maximum demand have to be watched closely. Also these records tell an interesting story to the maintenance organization of the condition of the equipment and the machinery it drives.

The charting of the factors bearing on production are so numerous, differing with the type of operations, that it is not possible to give

any sort of a comprehensive list of what should be dealt with; these must be chosen with regard to the information desired. Information gathered in this way shows a plant manager at a glance what is taking place and what the cost of different items is. A small plant does not need a complicated system; one that shows the prime factors of operation and costs, is all that is required. However, some plants go so far as to have a staff working on these records all of the time and have the results printed and used as the main record of the plant.

Recording and testing instruments must be taken care of if they are to work properly. Although the small mill cannot afford to have an instrument man such equipment should be put under the care of some one person, because it is not advisable to have everyone prying into an expensive meter with a cold chisel. The head electrician in the small plant is usually as good a man as any to handle the instruments. In any case, all delicate instruments should be kept locked and only one man have possession of the keys. Instruments should be housed in a dustproof cabinet, away from all vibration, and where they are not likely to be injured by falling objects.

To get better care of the instruments is not the only advantage of keeping the cases locked. For example, in a mill using heat-recording instruments, the night shift boss once turned in a chart showing a very fine record of control of the steam during the night. Unfortunately for, and unknown to him, the clock mechanism had been removed on the previous shift for repairs. It is seldom advisable to have the man who is responsible for the record supervise the instruments and remove the charts.

To be of value, charts from recording meters must be systematically filed where they can be easily located for reference, and not just piled out of the way in some corner. If a firm goes to the expense of buying valuable instruments, any money spent on their care and on the methods of extracting the most value from them, is well spent.

A record of steam or fuel oil consumption, where used in a process, is almost a necessity, as it gives probably the most vital factors of production. An accurate record, when checked against what was thought to be an intelligent guess, is likely to be an eye opener. For example, in one case a meter was installed in the fuel oil line to a kiln. No record had been kept beyond jotting down the amount supposed to be in the tank car. When checked by the meter it was found that the car did not always contain its full quantity. Further investigation disclosed a considerable amount of water with the oil. Also, records of production at different temperatures indicated that as good results could be obtained at a considerably lower heat, with a correspondingly decreased fuel oil consumption.

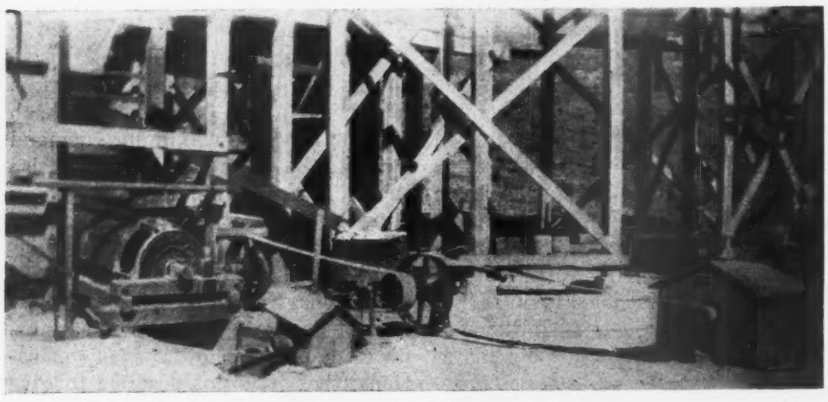
Why the Small Plant Cannot Neglect Maintenance

Because a mill is small, and with new equipment running smoothly, is not a condition that should permit maintenance to be neglected. If nothing is done the time will come when extensive repairs cannot be avoided, and often must be made when they will interfere most with production. The far-seeing superintendent will, before this time, have his millwrights and electricians constantly looking for trouble, because in a mill the best way to avoid trouble is to look for it, instead of relying on the time-honored method of not troubling equipment until it troubles you. Needless to say, when equipment which has been neglected in this way does begin to cause trouble it usually seems that the trouble begins to happen almost everywhere at once.

Plants which have tried out the plan of giving careful attention to equipment to see that any of the miscellaneous little things, which, if neglected, will cause trouble, find that this plan more than repays itself through decreasing breakdowns, interruptions to service, and interferences with production. The cost of a repair is much more than merely the cost of the time of the maintenance department and of the material used, if the men in a large section of the plant are waiting idle for the equipment to start up again.

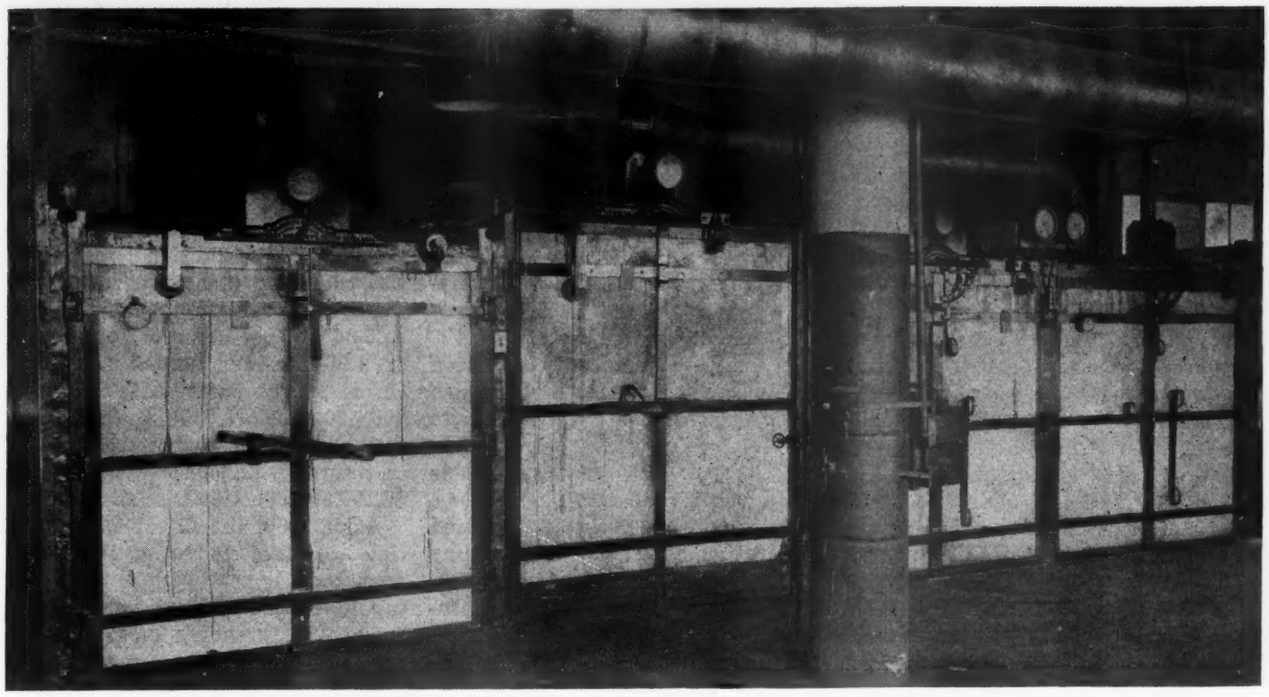
The number of men and the extent of the organization of a maintenance department in a small plant depends upon its size and type and the amount of work to be done. Sometimes a man or two with all-around experience constitute the nucleus of the departmental organization with the superintendent or his assistant directing the work. Increases in the force for special jobs are made by taking a helper from some other department or hiring a man temporarily.

These men, whether primarily electricians, millwrights, or steamfitters, should be instructed in the difference between the maintaining and the repairing of motive equipment and its associated connections. They should be encouraged in the reading of technical journals bearing on their occupation and their industry. One way of doing this is for the firm to subscribe to a few good journals, and distribute them among the various departments with the suggestion that the men mark articles of interest and discuss them thoroughly with the man who has supervision over their work. Reading publications dealing with an industry or with special classes of work is one of the best methods an industrial man has to keep abreast of new developments and applications of equipment.



The answer to the question of whether to use group or individual drive depends upon the operating conditions.

In this case of a mill feeding a screen each is driven by an individual motor. Because neither can operate without the other, it would have been more economical to use a single motor connected to a jackshaft to drive the two pieces of equipment.



This view shows the four electrically-heated japan baking ovens after they had been installed in one group and additional heat insulation applied to reduce the radiation losses, as explained in the text.

Here is an instance where

Reducing Heat Loss from Electric Baking Ovens

resulted in a yearly saving of $2,200 in operating costs on an installation of four ovens, at a cost of $90 for labor and material

By C. D. CORWIN

Works Engineer, Corona Typewriter Co., Groton, N. Y.

RECENT rearrangement of our baking ovens and some comparatively inexpensive alterations, based on the results of an investigation, rendered it possible for us to make a very much worthwhile saving in the cost of operation. These ovens, of which there are four, are employed for baking the varnish or japan finishes on our typewriter parts, and are of a type commonly used for this purpose. Three of the ovens originally had the following outside dimensions: Height from floor to top, 6 ft. 5 in.; depth from front to back, 6 ft. 4 in.; width 6 ft. 10 in. The fourth oven had a height of 7 ft.; depth 6 ft. 4 in.; width 6 ft. 5¼ in.

The walls of each oven are constructed of black sheet iron inside, backed by sheet asbestos, with room left for air spaces, and have a sheet galvanized iron external casing. The thickness of the walls was about 3 in. The ovens are of the sectionalized type and due to this construction may easily be taken apart and reset should occasion require it.

Gasoline gas was originally used for heating them, but in 1916 this was abandoned in favor of electric heat. The heating coils and controls installed at that time were made by the General Electric Company. In addition, the ovens are equipped with Schaeffer and Budenberg recording thermometers, Tycos heat controllers and mercury thermometers.

For several years, the ovens were located separately at various places in the finishing department, but by reason of a general rearrangement of all of the equipment in this department, it was found feasible to place the four ovens in a row, as shown in the illustration at the beginning of this article. This grouping facilitates the handling of work in process and also gives a much better appearance to the department.

Appreciating the fact that electric heat is costly and that wasted heat represents dollars, a study was made in order to determine the radiation losses from the ovens.

The first tests consisted of permitting each oven and regular load to reach the operating temperature of about 400 deg. F. and then measuring by means of recording and indicating kilowatt-hour meters the energy input required to maintain the ovens at the working range of 350 deg. F. to 400 deg. F.

Part of the energy supplied to an oven is lost by the heat contained in the circulating air which passes out the uptake stack; another part passes to the floor and is carried away by conduction; while a third and greater part is lost by radiation from the walls and tops of the ovens. The object of our study was to reduce this radiation loss.

During regular production as well as during the tests mentioned above, the temperatures at various points on the sides and tops of the ovens were taken by means of mercury

thermometers immersed in oil. It was found that an average temperature of 170 deg. F. existed on the outside of the walls, 190 deg. F. on the doors and 190 deg. F. on the tops of the ovens. The room temperature is usually about 70 deg. F.

An exact radiation factor for sheet galvanized iron was not available, but for our purpose it was thought that sufficiently accurate results could be obtained by assuming a factor that closely corresponds to one used for cast iron painted with aluminum bronze.

This factor for flat surfaces and for a temperature difference of about 100 deg. is approximately 1.9 B.t.u. radiated per square foot per degree difference in temperature.

Computing the B.t.u. lost by radiation gave results indicating a total loss of 160,735 B.t.u. per hour for every hour that the ovens were actually in use. As one kilowatt-hour is equivalent to 3,415 B.t.u. this represented a loss of 160,735÷3,415 =47.07 kw. hr. At a power cost of $.035 per kilowatt this loss amounted to 47.07×$.035=$1.65 per hour for four ovens, or approximately $.41 per oven-hour.

The actual oven-hours per day vary somewhat throughout the year, but will average about 20 per day, 300 days per year. According to these figures radiation from the ovens was causing a loss of 300×20 ×$.41=$2,460.00 per year.

In order to reduce this loss it was apparent that more or better insulation was required. The location of the ovens was such that their backs, after insulating, would form a partition between a hallway and the oven room proper.

Simple tests were made to determine the relative heat conductivity of Pyrobar. This is a gypsum-base product used extensively for partitions which carry practically no loads. These tests demonstrated that the heat conductivity was very low and as this insulation was to be finished with plaster on the hallway side, Pyrobar blocks measuring 12 in. by 24 in. by 4 in. were used.

Considerable old, air-cell pipe covering was also available and this was flattened out and placed against the outside walls of the ovens so as to form a layer approximately 1 in. thick. The Pyrobar blocks, laid in cement-sand-lime mortar, were placed against this.

The ovens were reset so that there was, on the average, about 1½ in. of space between them. Inasmuch as we do not always operate all of the ovens at the same time, we filled the space between them with scrap, air-cell insulation mixed with asbestos-fiber cement.

On the hallway side the insulation was given a scratch coat and a finish coat of plaster and then painted to match other partitions in the factory. A rear view of the ovens is shown in one of the illustrations. The tops of the ovens were covered with asbestos-fibre cement, making an insulating coating approximately 3 in. thick. The doors were insulated on the inside by a 2-in. sheet iron envelope packed with the asbestos-fibre cement.

We allowed a week for the insulation to dry out thoroughly before measuring the heat loss. Another test then showed that practically no rise in temperature took place on the side-wall surfaces. The doors showed a temperature rise of 30 deg. F., due quite largely to the fact that their construction was such that continuous metal existed in many places from interior to exterior surfaces. The tops of the ovens showed a rise of about 15 deg. F.

For a 30-deg. rise the radiation factor is 1.55 for flat surfaces; as these are so close the loss after putting on the additional insulation was computed using the factor 1.6. The loss by radiation was figured to be 5.04 kw. per hour for four ovens, or 1.26 kw. per actual oven-hour. On a yearly basis this would be 300×20×1.26×$.035=$262.50. The net estimated yearly saving is, therefore, $2,460.00 — $262.50 = $2,197.50. The job cost about $90.

Aside from the direct saving the time required to bring the ovens from room temperature to the working temperature was also shortened. The foregoing shows the saving on a relatively small baking installation. The quantity of heat wasted in baking and similar operations in industrial plants is undoubtedly quite large and in many instances a little thought and planning will make possible a saving that is many times greater than the necessary investment.

The backs of the ovens form one side of a hallway leading into the finishing department.

After the additional heat insulation had been put on, scratch and finish costs of plaster were applied over it and then painted to match the other walls and partitions.

Practical advice on

Brush and Commutator Maintenance

including the more important things to watch for and how to go about checking them in case of commutation trouble

By E. S. HOWE
Service Manager, Westinghouse Electric International Company, Mexico City, Mexico

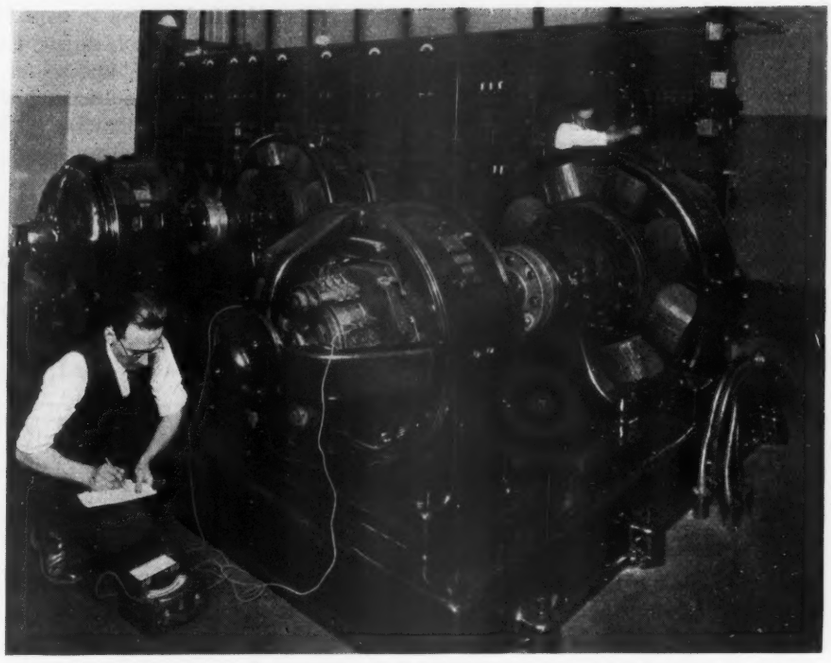


Fig. 1 — Determination of the proper position of the brushes by "kick neutral" is the easiest, although not the most accurate, method. The set up shown here is given in detail in Fig. 4.

SINCE the general adoption of auxiliary commutating poles, great progress has been made in obtaining sparkless commutation under varying load conditions. During this period manufacturers of brushes have made minute studies and analyses of types, grades and qualities of brush materials and commutating conditions. The operating man had best adhere closely to the instructions of brush manufacturers regarding the use and application of the different grades of brushes. There is little to be gained by individual experiments unless it is based on the huge mass of information and experience already collected by the brush manufacturers. There are, however, certain points that may well be considered in an analysis of commutating troubles and which help to make the study a logical one and not a matter of pure guesswork.

Proper Position and Spacing of Brushes Are Important

First of all carbon brushes should be evenly spaced around the commutator. Equal spacing is very important. When brushes fit properly in their holders, the most accurate method of spacing is to pass a narrow strip of paper under the brushes and entirely around the commutator. Paper from an adding machine roll or a few feet from the strip chart of a graphic meter is very convenient for this work. Mark on the paper the position of the toe or heel of one brush on each brush arm. On removal of the paper, accurate measurement will show the actual spacing and what adjustments are necessary for equal spacing. Repetition of the process finally results in exactly equal spacing around the commutator. Or, having determined the exact circumference of the commutator by means of the strip, it may be divided into a number of sections equal to the number of brush arms. The brush arms are then set to the marks on the strip.

Of course, the brush arms must be exactly parallel to the shaft. To check this point, turn the commutator until the brush arm under test has the toe of the brush along a mica segment. Parallel brush edges and mica segments will show immediately that the alignment is correct. If the brushholder studs are not parallel to the commutator segments, the brush span is increased as shown in Fig. 2. This is equivalent to using a thicker brush which increases the short-circuit current as is explained later in the article.

Current should divide itself evenly among the brushes. None of the brushes should take less than its full share, for that would throw excess load on the other brushes. To this end the spring pressure must be kept equal on all brushes. Small spring scales commonly used by amateur fishermen and sold in sporting-goods houses are admirably adapted for measuring brush pressure. The scale should be hooked to the brush or brush pigtail and not to the brush spring. The measurement is made by slightly lifting the brushes, one by one, and measuring the spring pressure directly on the spring balance. This method automatically corrects for the weight of the brush itself. The brushes on the top of the commutator add their weight to the spring pressure, while those underneath subtract their weight from the pressure of the springs. It is not sufficient to measure the force required to lift the spring alone because the friction of the brushes in their holders varies and vitiates any measurement of the spring tension alone.

An old rule for brush pressure was about a pound per square inch of brush surface or, slightly more pressure, if commutation continued unsatisfactory. This was when commutation requirements were not always sparkless from no load to full load and over. Such a lenient rule is no longer acceptable. Brush manufacturers have definite recommendations for pressure for any type and application of brush. These recommendations should be known and applied. Undercut commutators require less pressure than commutators with flush mica. Nowadays a manufacturer may recommend a pressure anywhere from ½ to 7 lb. per sq. in. Crane and railway motors require higher brush pressure than do stationary motors,

because of the vibration to which these motors are subjected. One brush manufacturer recommends a pressure of 3 to 5 lb. per sq. in. for crane motors and 4 to 7 lb. per sq. in. for railway motors.

Sparking due to high mica might be reduced with brush pressure in excess of the manufacturer's recommendation but obviously the really conscientious operator will not allow himself to be misled by such temporary improvement. He will correct the real trouble; that is, remove the high mica so as to make a permanent correction before abnormal wear takes place on the commutator.

Brushes must be of a size that will fit closely without binding in the brush holders. They must not be too big because then they will stick and not move freely up and down with the eccentricity of the commutator, if any exists, and also because the spring pressure will lose its full effectiveness. They must not be too small because then they will wobble about within their brush-holders, wearing their sides excessively and then naturally wearing new contact surfaces with the commutator. A new contact surface will, until worn in over the whole face of the brush, reduce the area of contact and hence the total commutating capacity of the brush. Furthermore, the slight cavity between the commutator and the part of the suface not yet worn in, becomes a fine pócket for the collection of dirt and the breeding of trouble. So careful attention to the fit of brushes in their holders is paramount.

There is no advantage in having a large clearance between the brush-holder and the commutator. A normal clearance of ⅛ in. is satisfactory. This amount may be varied slightly so as to make the clearance the same on the front and rear of the holder if desired.

The inclination of the brush is another important item for consideration. Inclination varies markedly with the quality and composition of the brush. There is no rule except to use the recommendation of the manufacturer for the carbon brush in question. I remember a rotary converter with unsatisfactory commutation and noisy operation, on which satisfactory commutation, quiet operation and smooth-running brushes were obtained simply by changing the direction of rotation of the armature. This had the effect of changing the angle of inclination of the brushes in regard to the commutator rotation. In short, if trouble exists, one of the points to check is the inclination of the brush used as compared with the maker's recommendations.

Methods of Checking Neutral Position of Brushes

In the older machines the best brush position for any given load was found by moving the brush rigging forward in the direction of rotation with increasing load on a generator, and backward from neutral with increasing load on a motor. Almost all modern machines have commutating poles or interpoles. Such machines require the brushes to remain exactly on the neutral at all loads. In a generator, the auxiliary pole or commutating pole just ahead of a main pole, in the direction of rotation, is of opposite polarity to that main pole. In a motor, the auxiliary pole is of the same polarity as the main pole of which it is just ahead. Proper commutating pole connections for the machines are sometimes permanently made in the factory. More often, since the ultimate direction of rotation desired is unknown, the only permanent connection is between the armature and interpoles. Both are reversed with reversal of direction of rotation so far as connection with shunt and series fields is concerned, but on the other hand remain in the same relation, one to the other. The commutating field connections should be carefully checked to insure that the fields have the proper polarity.

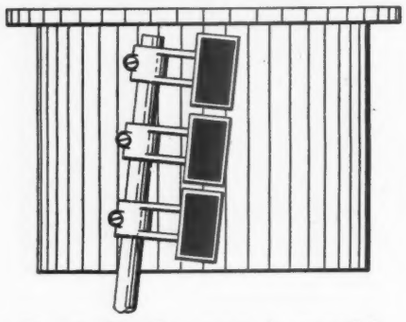


Fig. 2—Brushes must be parallel to the commutator segments.
If the brushes are not parallel to the commutator segments, the effect of greater brush width is produced, as is shown in the figure. This results in increasing the short-circuit current in the brushes, due to the fact that more commutator bars are spanned.

Templets are furnished so that brushes may be reset exactly on neutral, for the larger machines. Even when furnished these templets are often mislaid or otherwise not available and a check is desired to find the exact neutral, so that the brushes may be properly located on the commutator. Four methods are available: the hairpin method, the "kick" method, the two-directions-of-rotation method, and "running" neutral.

For the first method, a short piece of insulated wire is bent to form a hairpin with the ends spread apart about the width of a commutator segment. While the machine is running this hairpin is carried along the edge of the commutator near a brush. The point of least sparking denotes neutral. The brushes should then be moved to this spot and the hairpin again carried along the commutator edge until finally the test shows the minimum sparking to be under the brush. This method is open to the objection that two or more points of minimum sparking might be found and obviously the brushes could not be left permanently in two positions. If there is a hump in the commutating field of the machine, due to an improper interpole field strength, such a condition showing three points of minimum sparking is possible. Fig. 3 illustrates a condition of this character.

The "kick" method of determining neutral is applied without load and with the motor or generator at rest. All the brushes are raised from the commutator except two which are beveled to an edge. The leads from the armature are disconnected from the line. The two beveled brushes are connected to a low-reading voltmeter. The connections for this test are shown in Fig. 4. Full voltage is then momentarily applied to the shunt field and the "kick" or induced voltage is noted on the voltmeter. The beveled brushes are moved as need be until a position is found that shows no "kick" or voltage induced in the voltmeter circuit. This position is neutral and is the proper center line of the brushes. The objection to this method is that any deviation of the mechanical assembly or the magnetic circuit from exact symmetry would render inaccurate the readings at no load.

The third method is more difficult to apply but leads to more accurate results. The machine must be run as a motor during this test. It is run under load while the speed is taken. It is then run in the opposite direction, loaded with exactly the same load and the speed taken

again. If the two speeds are not equal, the brushes are moved and the two runs repeated until equal speeds are obtained in each direction. The precautions that must be observed are many. The line voltage must be the same during runs in each direction. The temperature of the machine must be the same. The field current must be the same. The bearings must be in excellent condition so as to give no change in friction. The relation or direction of shunt field and series field flux must not change. Equally important, the brushes must fit exactly in the brushholders, otherwise they will move and not hold the same contact surfaces during operation in the two directions.

The fourth method of finding neutral, known as "running" neutral, is based on the fact that if the brushes are in the correct no-load neutral position, no voltage will be generated by the commutating-pole flux when the machine is running on open circuit with the commutating winding separately excited. The connections for making this test are shown in Fig. 5. A beveled brush is placed in each of two adjacent brush arms, the same as for determining "kick" neutral. A low-reading voltmeter is connected across these brushes. The commutating field is disconnected from the armature and other windings and arrangements are made for exciting it with from 2 to 4 per cent of full-load current by use of resistors in series with the line voltage. The shunt field is separately excited and arranged with a reversing switch so that the polarity of the shunt field may be reversed at will.

The machine is then brought up to normal speed and by momentarily exciting the shunt field in a reverse direction, the main field poles are demagnetized, until no deflection shows on the lowest scale of the low-reading voltmeter. Any deflection then obtained by exciting the commutating poles will be due to the commutating-pole flux alone.

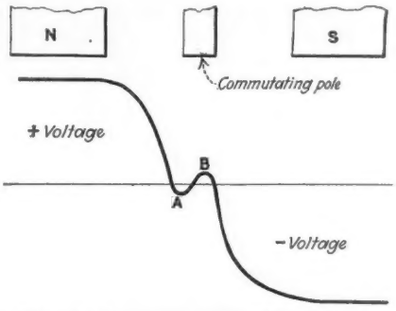


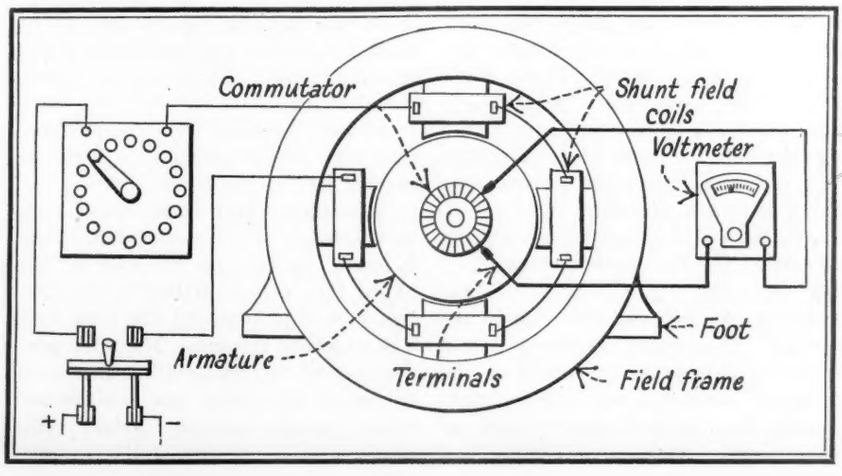
Fig. 3—In some cases the hairpin method of finding neutral will give misleading results.

If there is a hump in the commutating field of the machine, due to improper interpole or commutating pole strength, as at *A* and *B*, three points of minimum sparking at the hairpin may be obtained. The true neutral is midway between *A* and *B*.

Excite the commutating poles with about 2 per cent of their normal current and shift the brushes until no deflection is obtained on the lowest scale of the voltmeter. The residual magnetism in the main poles must be checked from time to time, keeping it at as low a value as possible by demagnetization, as has been explained. After determining the best brush position at the 2 per cent value of commutating pole excitation, repeat the test using about 4 per cent exciting current.

Fig. 4—"Kick" neutral is determined with the motor or generator at rest.

All the brushes are raised from the commutator, except two in adjacent arms. These brushes are connected to a low-reading voltmeter. Line voltage is temporarily applied to the shunt field and the kick or induced voltage noted on the voltmeter. The brush arms are shifted until no kick is noticed on the voltmeter.



If no difference is found, reverse the current in the commutating field and try again, still remembering to check the residual magnetism in the main poles from time to time.

This method gives very accurate results if carefully used. Since the machine is running, errors due to brush resistance or to a brush resting on mica only are eliminated, thereby making this method preferable to the "kick" method.

Modern Brushes Do Not Require Lubrication

Not many years ago it was considered necessary to lubricate brushes to obtain satisfactory results. Undoubtedly the lubrication helped commutation but it brought with it extremely undesirable contingencies. The lubricant worked into the commutator mica and greatly shortened its life; likewise it helped attract dirt which collected under the brushes. Now lubrication is no longer supplied by hand. The necessary lubricant is applied by the brush itself. This lubricant consists of graphite which is a constituent part of the brush. It varies in amount according to the use for which the brush is designed. Brushes for flush-mica commutators need a high percentage of abrasive material to keep the mica worn down and hence less graphite, while brushes for undercut commutators are designed to give minimum wear and so they have a high percentage of graphite or lubricant.

The manufacturers of brushes decide what composition their own brushes of various grades shall have but usually guard the analysis with great secrecy. The operating man must be content with the manufacturer's general description of his brushes and his specific recommendations for their uses. These recommendations are based on long experience and tests. They should be followed very carefully.

Not only is the load current carried by the brushes but in addition the armature coil or coils momentarily short-circuited by the brush as the corresponding commutator segments pass under the brush produce a short-circuit current that passes into and out of the surface of the brush. This short-circuit current serves no useful purpose and the more it can be reduced the better. While the coils are short-circuited by a brush a current will flow in them if they are cutting any lines

of flux at all. Even though they are then in the commutating zone midway between main poles there still remains a certain amount of magnetic flux, the cutting of which by the coils sets up a short-circuit current. This current is shown flowing around the coil in Fig. 6.

Methods of Reducing Short-Circuit Currents

One brush manufacturer claims for his brush of a certain grade that the resistance crosswise is high and the resistance lengthwise is low. Such an arrangement puts a high resistance in the path of the short-circuit current and a low resistance in the path of the main current.

Another method of obtaining a similar result is to cut a narrow slot lengthwise in the brush, beginning at the surface and rising for a considerable distance into the interior, as shown at *A*, Fig. 7. This slot makes a very slight change in the path of the main current but it materially lengthens the carbon resistance path of the short-circuit current and so tends to diminish that useless current. Another advantage of the slot is the additional radiating surface that it provides. However, the slot has disadvantages in that it reduces the brush surface in contact with the commutator, weakens the brush, and provides a pocket for the collection of dirt.

A third method of reducing the short-circuit current is to reduce the thickness of the brush. This change makes the brush span a lesser number of commutator bars. At *B*, Fig. 7 the short-circuit current is produced by the voltage of two coils in series, while in *C* it is reduced to one coil because there is only one coil spanned by the brush. This third method might not be feasible to adopt because the reduction of brush cross-section might lower the carrying capacity of the brushes to such an extent that they would be unable to carry the required current. Furthermore, reduced thickness of brushes would necessitate new brushholders, which take time and money to obtain and install. A certain modification of this method will ordinarily be satisfactory, but the brushes will require frequent attention. It consists in beveling the brushes on the side where sparking occurs in order to obtain the reduced span at the contact surface, as shown at *D*, Fig. 7. This permits the use of the same brushes and brushholders which were supplied with the machine. The bevel of the brushes must be maintained.

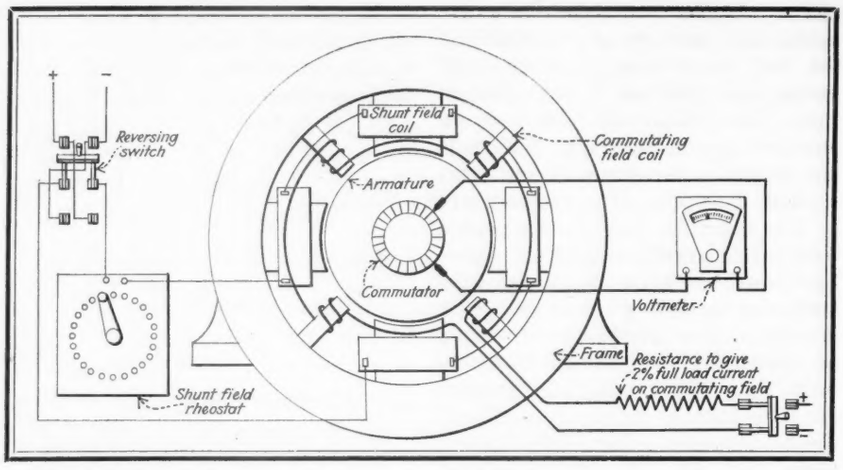


Fig. 5—"Running" neutral is determined while the machine is driven at full speed.

The method shown in this diagram is based on the fact that if the brushes are in the correct no-load neutral position, no voltage will be generated by the commutating-pole flux when the machine is running on open circuit with the commutating-pole windings separately excited.

Selection and Maintenance of Brush Shunts

When it comes to the subject of pigtails or shunts for brushes, the operator of electrical machinery must use his best judgment and depend upon his practical experience. Shunts are made of many strands of small copper wire to give flexibility to the connection between the slightly moving brush and the rigid brush arms. It is essential that the brush be allowed slight movement to conform with the commutator irregularities, so as to obtain good contact at all times and hence give sparkless commutation. To insure this freedom of movement, the flexible shunt best serves the purpose. Its many small copper wires are sometimes made into flexible copper cable and sometimes into braided copper ribbon. These small wires are, however, particularly susceptible to mechanical injury and to oxidation, and should be protected against these whenever unfavorable conditions are present.

Mechanical damage to the shunts is caused for the most part by chafing against other parts of the machine, as for example the brush spring. Stationary machines should have their brushes inspected at the original start-up and the shunts should then be arranged to clear all other parts without any rubbing, and should remain so until the next inspection period arrives. Brushes for more severe service, as in vehicles, may have the shunts especially protected. A number of devices are in common use and may be supplied by brush manufacturers if desired. One way of protecting flexible shunts is to cover them with insulating porcelain beads. Another device consists of a spiral of enamel-insulated steel wire which surrounds the shunt.

Oxidation may be due to moisture, or acid fumes, or may be caused by internal heating due to the flow of excessive current through the shunt. To protect them against oxidation the individual copper wires of the shunt must be tinned. This should be done when the brush is manufactured. If done afterwards the tinning process is likely to make the shunt stiff. With care it is not an impossible task, however, to apply a suitable tinned surface to the shunt.

The terminal on the end of the shunt, which is fastened by a screw to the rigid part of the machine, seldom gives any trouble but in contrast, the terminal that fastens the shunt to the carbon brush is a very probable source of trouble. Conditions surrounding this contact point must be studied and watched by the operating man. These contacts may be all right when the brushes were originally installed but who can say that they will remain so through the normal life of the brush?

A common and inexpensive contact between shunt and carbon brush is made by forcing the end of the shunt into a hole drilled in the carbon and then tamping the hole with a conducting cement. The very general use of this method has proven it to be a successful one. However, when brush trouble arises this point should be carefully investi-

gated in the various brushes. Obviously the cement cannot be put into the hole under a pressure greater than the breaking tensile strength of carbon and so there is a very definite limit to the contact that can be made by this method. Expansion of the copper of the shunt, the cement that fills the hole, and the carbon of the brush cannot be exactly the same and so brushes of this type that have been subjected to excessive heat or extreme overload may be ruined at the contact point, due to oxidation during undue expansion and contraction.

Installation and Care of the Brushes

In another method the shunt is fastened behind the head of a rivet that passes through the brush. When the rivet is headed over on the opposite end under pressure, heat is also applied to melt the conducting cement or solder around the shunt and the rivet, so that it will make intimate contact with the carbon material of the brush.

This type of contact is more expensive to apply but is stronger than the one described in the preceding paragraph. Its advantages are due to the fact that the pressure applied is limited only by the crushing strength or compression strength of carbon, which is far greater than the tensile strength that limits the first method. Furthermore, the moderate heat used in fastening the shunt insures that the binding material will completely fill all the space between carbon and shunt. Due to the higher pressure used the danger of oxidation during expansion and contraction is greatly reduced.

A few years ago the subject of picking up copper by carbon brushes received much more attention than it does today due, of course, to the fact that it is a much less prevalent trouble today than it used to be. Picking up copper tended to disappear with the reduction in application of lubricants to commutators, and with the introduction of interpoles. Its causes are (1) excessive current passing between brush and commutator; (2) collection by the lubricant under the brush of fine copper particles, produced by the abrasive action of hard carbon brushes; and (3) electrolytic action between the commutator and the brush or lubricant, or both.

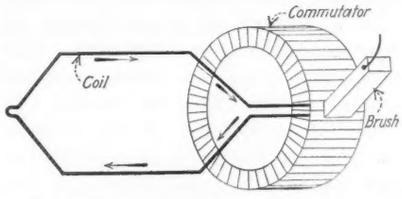


Fig. 6—If the coils short-circuited by a brush are cutting any lines of force, a short-circuit current will flow as indicated. This short-circuit current serves no useful purpose and the more it can be prevented the better.

Excessive currents may be due to overload on the generator or motor or, much more probably, they are due to excessive short-circuit currents from the coil or coils short-circuited by the brush. When this is the case, the picked-up copper is deposited more heavily on one-half of the brush surface than on the other, since on one-half the short-circuit current and the main line current are added together while on the other half the two currents are opposed to each other and the resultant current is much less, being only the difference of the two currents. This is illustrated in Fig. 9. With interpoles the short-circuit current is kept within smaller limits and so the brushes are not so prone to pick up copper.

Brushes that are strongly abrasive wear the commutator away in minute copper particles. Some lubricants hold these particles onto the brush contact surface and soon an irregular copper plating is formed. Again, where the brush material and the lubricant form an electrolytic cell with the copper commutator, the electric current developed tends to deposit copper on all of the brush contact surfaces. Because there is a short-circuit current under all brushes there is current flowing from the copper commutator to the carbon brush whether the brush is on the positive or negative side of the machine. As a consequence there is a tendency to deposit copper on the surface of all the brushes. Remedies are found in changing the grade of brush or lubricant. As an example, undercutting the mica would allow the use of a different grade of brush. Also, using a brush composed of a graphite mixture would require no lubrication other than that furnished by the brush itself.

When new carbon brushes are used, they must be ground properly to fit the commutator. If they are sandpapered by hurriedly drawing a strip of sandpaper in one direction and then the other, under the brush, an exceedingly poor contact results.

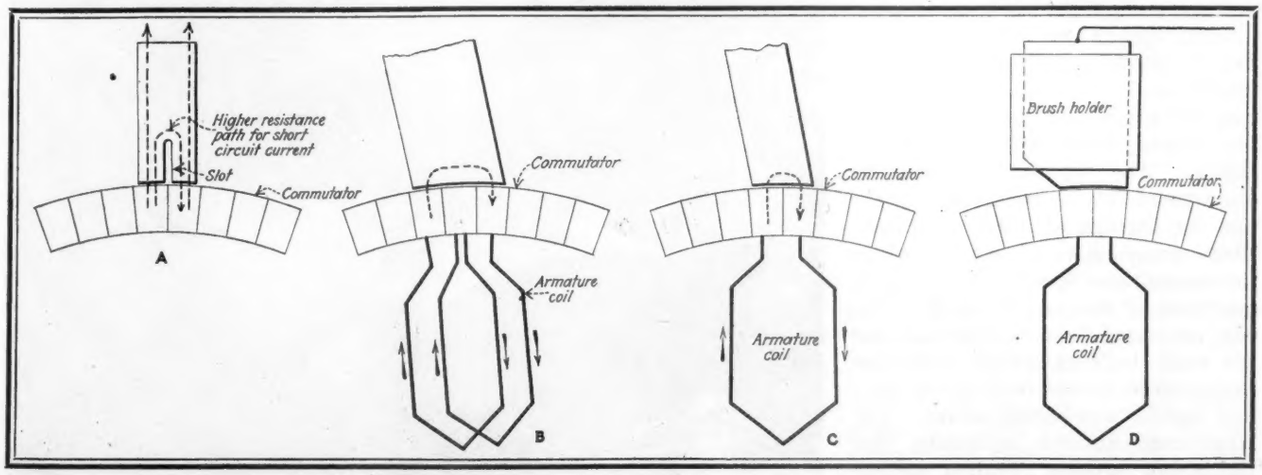


Fig. 7—Some of the methods that may be used to reduce the brush short-circuit currents, are shown in these diagrams.

In diagram *A*, a slot is cut lengthwise in the brush thereby increasing the path of the short-circuit current. Diagrams *B* and *C* show how a brush spanning more than two commutator bars increases the short-circuit current due to the fact that there are two coils in series. To remedy this condition, bevel the brush on the side on which sparking occurs so as to reduce the span at the commutator, as shown at *D*.

The carbon brush does not exactly fit its brush holder and with the sandpaper pulled in one direction and then in the reverse direction, the carbon brush moves back and forth in the brush holder by the amount of clearance or play and a composite surface results corresponding to the various positions occupied by the brush. Such a method, although frequently, used gives very poor results.

The proper method is to grind in the brushes by pulling the sandpaper in one direction only, as shown in Fig. 8. The direction of pull should correspond with the direction of rotation of the commutator. In the case of a reversing motor, one of the two directions might preferably be chosen for sanding one-half of the brushes and the other direction for sanding the remaining brushes. One brush at a time should be sandpapered. The sandpaper should be cut into strips slightly wider than the brush. The fingers of the right hand should lift the brush in question 1/16 to 1/8 in. from the commutator. The left hand should then pass the sandpaper strip, with the sand side toward the brush, between the brush and commutator until the fingers can grasp only a remaining inch or so of sandpaper. The right hand should then lower the brush on to the sandpaper strip and apply enough pressure so that the left hand may just pull the sandpaper under the brush through its whole length. The operation is then repeated again and again until the brush surface is ground to conform with the commutator. In order not to round the edge of the brush, the sandpaper must be held at the surface of the commutator throughout the operation.

Maintenance and Care of Commutators

Commutators are built of alternate segments of copper and mica insulation. The thin segments of mica are often held in place between the copper bars with high-grade shellac. The segments are tightly compressed to a permanent position by V-rings of varying design. This compression is applied when the commutator is hot and on larger machines, if the best building methods are used, several tightenings are made between which times the commutator is revolved at its normal speed and temperature. On large commutators especially, the tightening process requires an extended seasoning period. In some cases this period is not terminated until after the machine is installed and regularly operating, so that the operator has to complete the process himself.

The manufacturer will supply information as to the maximum permissible force that may be used with a wrench of given length to tighten the bolts or ring nuts. For a certain type, the total pressure applied to the ring nut should not exceed 20 to 40 tons. If the stretching point of the bolts is reached before the safe working strains of the V-rings, then sometimes gains may be made by substituting hardened steel bolts for others less strong. Likewise, through bolts may replace stud bolts. It is absolutely essential that commutators be made tight or else they will constantly change and give poor commutation. On the other hand, enormous stresses are set up by the tightening process, which are augmented by temperature expansion and the centrifugal force of rotation. The disaster caused by a bursting commutator is serious in the extreme and so operators must never exceed the pressures allowed by the manufacturer.

Bolts must be tightened immediately after the machine has been run at full speed and has attained a commutator temperature of 80 to 100 deg. C. It may be difficult to attain this temperature and various methods may be adopted, such as overload current, bad commutation with brushes somewhat off neutral, enclosure of the commutator, external heating with grids, steam pipes or flames, or friction from blocks of wood. Oftentimes special arrangements are required to stop the machine quickly before it cools after the temperature run.

When the commutator has been tightened in this manner it will be found to have high bars or to be out of round and must be ground. If possible this should be done without current in the commutator. Commutators can be ground when alive by insulating the tool holder. A carborundum stone is a good insulator itself, but emery paper is not. Small armatures can most readily be put in a lathe and revolved at full speed while being stoned. Full speed is essential so as

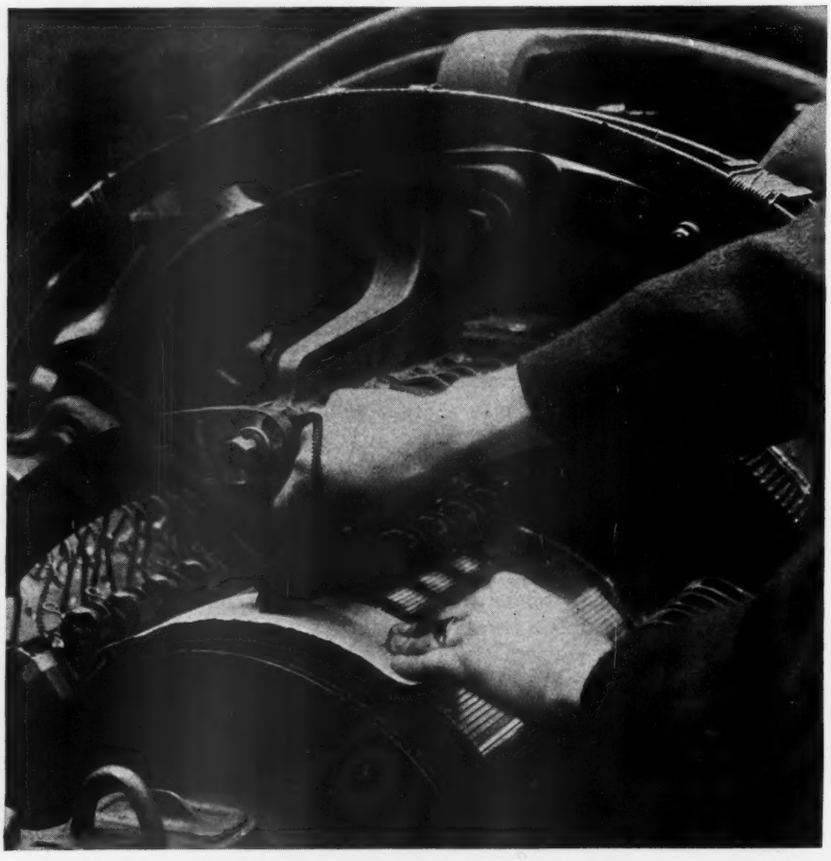


Fig. 8—Points to observe when sanding brushes.

(1) The sandpaper should be pulled across the brushes in one direction only. (2) The direction of pull should correspond with the direction of rotation. (3) The sandpaper should be held against the surface of the commutator, as shown in the illustration throughout the work.

to simulate the actual operating conditions as nearly as possible.

Grinding Commutator Is Better Than Turning

A little thought will show it is impossible to turn a commutator exactly round with an ordinary lathe tool. The tool will cut through a copper segment with a certain spring. Suddenly it encounters the mica and springs back still more. As it leaves the mica and enters the softer copper, it springs slightly forward again, gouging into the copper. So a commutator turned with a lathe tool has high mica even from the start, albeit very slightly. Such is not the case with a commutator ground true with a stone or grinding wheel.

Usually it is convenient to tie sheets of card board to the risers or armature leads to prevent dust from the stone and copper from getting into the armature winding. A bag is tied under the commutator to catch most of the dust just as it leaves the stone. The stone is applied to the commutator just under the center on the side traveling down. Just below center is preferable because the stone will not stick if excess pressure is applied to it.

Some operators prefer a carborundum wheel of grit No. 70 in place of a grinding stone. The wheel should travel in the same direction as the commutator travels. It is obviously more work to set up a wheel and its rotating mechanism.

A very good stone to use is No. KWR-40 carborundum stone. It is mounted in a tool holder and operated just like a lathe tool. If the beginner will content himself with not trying to force his grinding stone into the work, but will proceed slowly and with caution, he should from the very first obtain good results. He must, however, give careful attention to the finishing methods.

After the commutator has been ground absolutely round, it should be smoothed with carborundum paper, No. 70 grit, and then with No. 00 sandpaper. These abrasive papers work best when pressed against the commutator under a block of wood concaved to the curve of the commutator. After a thorough polishing as it revolves, the commutator will literally shine and reflect like a mirror.

It is now time to undercut the mica. There are several motor-driven tools for this purpose on the market. A good one consists of a tiny circular saw driven through a flexible shaft by a small motor. Ordinary hacksaw blades are the right thickness for mica segments; so a broken one makes an excellent tool to scrape away the mica. As the work proceeds and the end tooth on the hacksaw blade gets dull it may be broken again and a new tooth put into use. No set rule can be given for the depth to cut away the mica.

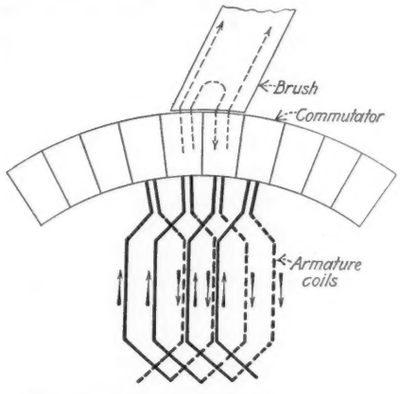


Fig. 9—Copper deposits on the brushes are often due to excessive currents—usually excessive short-circuit currents.

In this case the copper is deposited on the contact surface of one-half of the brush more heavily than on the other. This is caused by the fact that on one-half of the contact surface of the brush, the short-circuit current is added to the load current, while on the other half the opposite is true as shown in the diagram.

The writer has often obtained exceptionally good results by simply scraping away a few thousandths of an inch with a pen knife. For good and lasting results 1/32 in. or 1/16 in. is not too much. Depth of cut is not required for an electrical reason, but rather because it allows a triangular file to properly bevel the adjacent copper segment edges and because it leaves a bigger pocket of air which has a cooling effect on the brush while passing underneath.

There is a theory that mica slots should not be undercut to the extreme outer edge of the commutator because so doing increases the liability of flashovers from the commutator to the front V-ring. On motors or generators that will operate in dirty or oily locations this rule is well applied. After the undercutting is done, a small, smooth triangular file is used to chamfer the edges of the copper bars. Martindale or Keller Bros. commutator files are especially adapted for this purpose. After chamfering, the commutator will require smoothing again. No. 70 grit carborundum paper must be used. Sandpaper is not suitable because it will not cut off the minute copper burrs made by the triangular file. This little item of chamfer, improperly finished, has caused more than one otherwise well-done job to result unsatisfactorily. It must not be overlooked.

Not all commutator troubles originate in the brushes or commutator. A well-known source of trouble is in the soldered joints of the risers from the commutator necks, or of the cross connectors of the armature, perhaps at the opposite end from the commutator. Another source is in unequal magnetic conditions in the various field poles. Still another is in the contact surfaces of the several parallel current paths from the brushes to the common collector. In searching for causes of commutation trouble, it is well to consider that the brushes are in parallel paths and for correct commutation these paths must have nearly equal resistance and magnetic conditions both within and without the armature.

There are other causes external to the commutator and brushes which should be considered when hunting the reason for poor commutation. A common one is an open circuit in an armature coil. Sometimes this may be cured by shorting out the coil, but obviously the more satisfactory remedy is to rewind the armature. Unequal air gaps often cause sparking, the cure for which is to shim up the short poles or grind off the faces of the long ones. Worn bearings are frequently the cause of unequal air gaps. Excessive vibration sometimes causes commutation trouble. This may come from the pound of a reciprocating engine driving the machine, an unstable foundation, or even a poor belt lacing. Short-circuit current between brush studs is usually caused by an unbalanced armature winding. Obviously the best solution in this case is to consult the manufacturer of the machine.

It is well to remember that constant sandpapering should be avoided. Good results are sometimes obtained by simply letting the commutator alone, so it may get its proper, natural finish—a beautiful, deep chocolate color.

Editors' Note: Acknowledgment is made to the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., for some of the illustrations used in this article.

This article explains

What Re-Entrancy Means in Lap and Wave Windings

with some examples and simple rules governing the relations and principles involved in connecting singly and doubly re-entrant windings.

By A. C. ROE
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and
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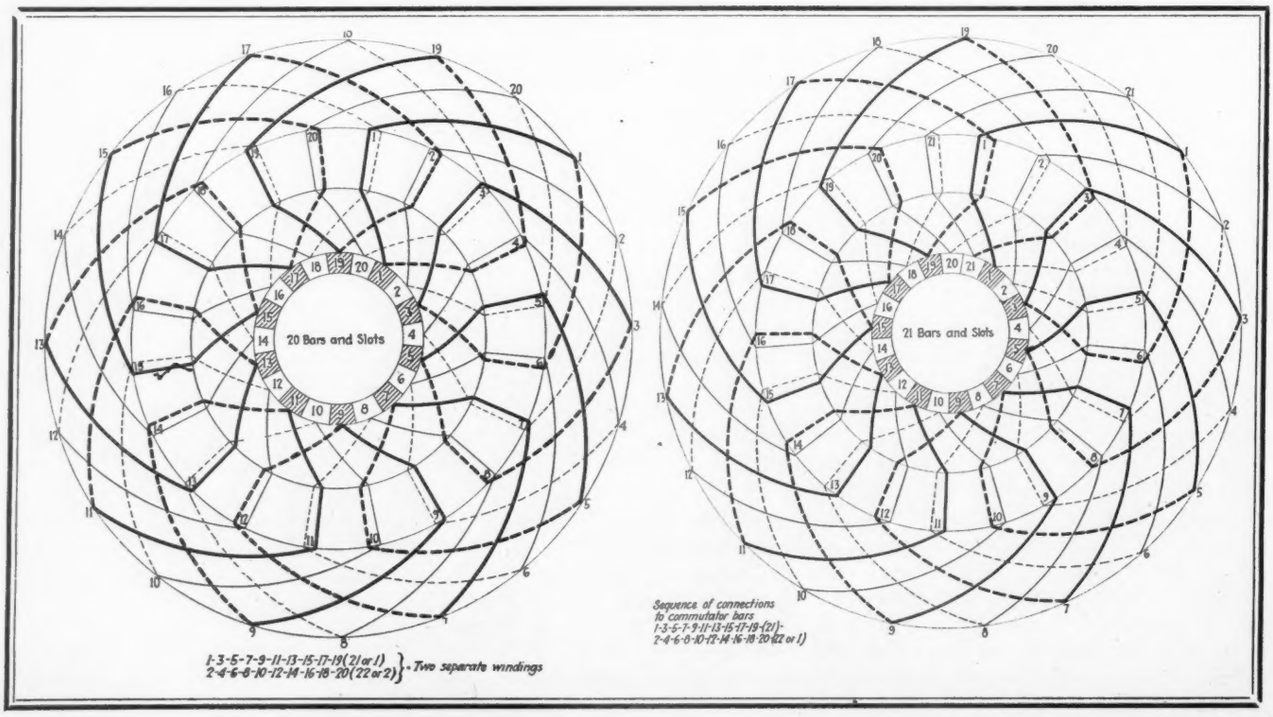
HERE ARE SOME points to bear in mind regarding re-entrant windings:
(1) In all cases, regardless of the number of poles, the winding will be singly re-entrant when the lead pitch expressed in bars, is an odd number, such as 9, 11, 13, etc. The winding will be doubly re-entrant when the lead pitch in bars is an even number, such as 8, 10, 12, etc.
(2) From the above it follows that a singly re-entrant winding is one in which all the coils are passed through in regular sequence before the winding closes on itself, while a doubly re-entrant winding is one in which the winding closes on itself after passing through one-half the coils, thus forming two separate windings which are not interconnected.

TO HELP eliminate some of the confusion in the minds of repair shop men regarding re-entrancy as applied to single and double (or duplex) lap and wave windings, some examples of typical windings and rules for connecting them will be discussed in the following pages.

All single, closed-circuit windings, that is, lap windings in which the top and bottom leads of any one coil attach to adjacent bars, and two-circuit (single) wave windings, where the coils in series are equal to one-half as many coils as there are poles, end on a bar either one bar ahead of or behind the one started on. When the above conditions are fulfilled, the winding will be singly re-entrant regardless of the number of bars.

In a lap winding, when the top and bottom leads of any one coil connect to bars *1* and *3*, that is when there is one bar between the top and bottom leads for any one coil, the winding is called duplex, and will have twice as many paths or circuits as poles. If the total number of bars is an even number, the winding will be doubly re-entrant. Fig. 1 shows a double lap winding (eight-circuit) four poles, with 20 bars and slots, the coil pitch being 1-and-6. The heavy line coils show one winding and the light lines the other winding. When any duplex winding is doubly re-entrant the armature will have two distinct and separate windings. In Fig. 1 the full lines represent the top halves of the coils, and the dotted lines the bottom coil half. In Fig. 1 the top lead of coil *1* connects to bar *1* and the bottom lead of coil *1* connects to bar *3*. Following this path we pick up coil *3*, bar *5*, coil *5*, bar *7*, coil *7*, bar *9*, bar *11*, coil *11*, bar *13*, coil *13*,

Figs. 1 and 2—These diagrams show, left, a four-pole duplex (eight-circuit) lap winding that is doubly re-entrant, and, right, a duplex (eight-circuit) lap winding that is singly re-entrant.



bar *15*, coil *15*, bar *17*, coil *17*, bar *19*, coil *19*, the bottom lead connecting to bar *1*. Thus, after passing through ten coils, the winding closes on itself, but there is another winding sandwiched in between the first one traced out. Starting on bar *2* and tracing through, we pick up ten coils and end on bar *2*. These two windings do not interconnect and if a test light were placed across bars *1* and *2*, the lamp would not light. If the test were made between bars *1* and *3*, or *2* and *4*, a light would be had. The notation given on Fig. 1 gives the circuit from bar to bar of each winding.

Next, consider Fig. 2 which shows a four-pole lap winding with eight circuits, and 21 bars and slots. In this winding coil *1* is connected to bars *1* and *3*. Starting at bar *1* the circuit progresses to bars *3*, *5*, *7*, *9*, *11*, *13*, *15*, *17*, and *19*, to bar *21* which is one behind the starting bar. Thus the winding does not end on itself, but continues on to bars *2*, *4*, *6*, *8*, *10*, *12*, *14*, *16*, *18*, *20*, and then to bar *1*, which closes the winding after passing around twice. This winding is said to be singly re-entrant.

From the above, the following rules for double or duplex lap windings can be given:

(1) A double lap winding can have any number of bars, odd or even, regardless of the number of poles.

(2) With an odd number of bars the winding will be singly re-entrant. With an even number of bars the winding will be doubly re-entrant; that is, divided into two separate windings.

(3) With a doubly re-entrant winding a light can be obtained, when testing out, only between bars spaced 1-and-3 apart.

(4) With a singly re-entrant winding the windings are interconnected; hence a light will be obtained between adjacent bars, and also between bars spaced 1-and-3. This latter is the correct light-out.

From the above it follows that when taking data the type of winding, that is, whether lap, single or duplex, singly or doubly re-entrant, can be determined by selecting any one coil and top lead, and lifting two top leads on either side of the top lead selected, which can be left in the bar. Then hold one test lead on this bar and try the adjacent bar on either side. If a light is obtained, the winding is single lap, but if a light is obtained on a bar that is 1-and-3 from the data coil lead bar, then the winding is duplex lap and the re-entrancy is determined by the total number of bars, as explained above.

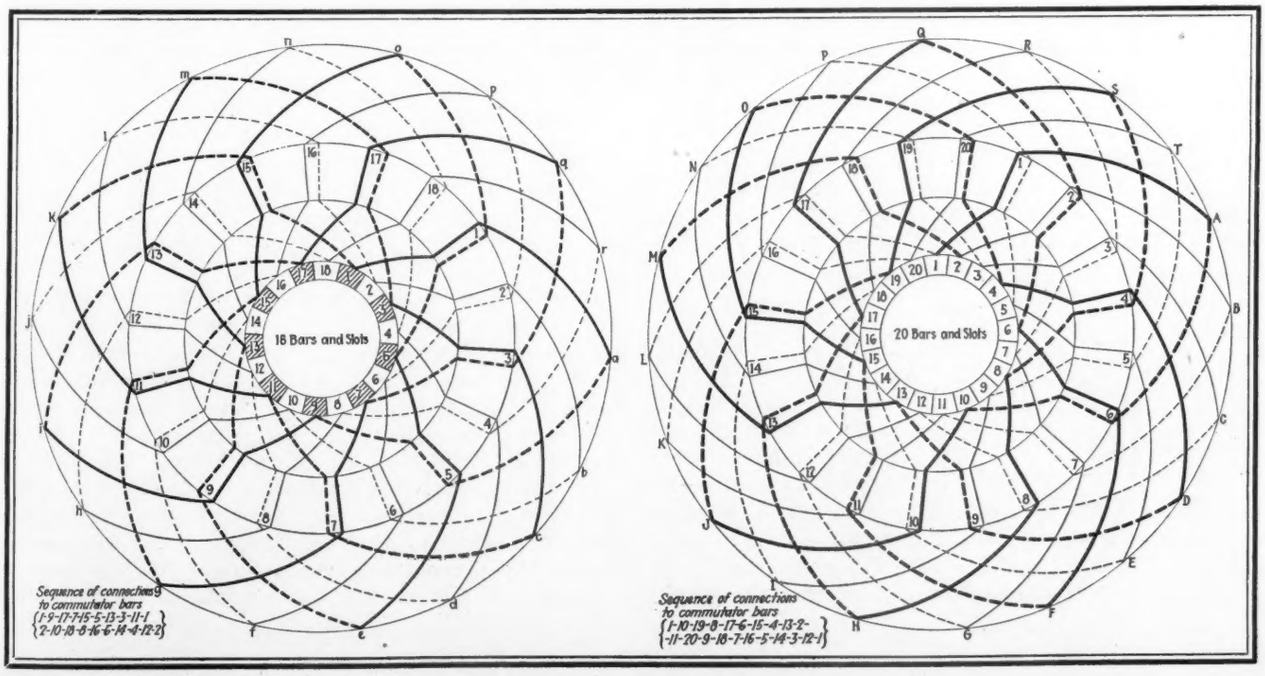
For duplex windings the brushes must be wide enough to cover at least one and one-half bars. The re-entrancy of a winding does not have any effect on the rotation or polarity of a motor or generator.

Fig. 3 shows a double-duplex, four-circuit wave winding, for four poles, 18 bars and slots, coil pitch 1-and-5, lead pitch 1-and-9. For a double wave winding, the total number of coils must satisfy the formula: $L=(B\pm2)\div P$, or the series of P coils must end two bars ahead of or behind the bar that the series started on. Then for Fig. 3 the formula becomes, $L=(18-2)\div 2=8$, or 1-and-9, or L could be $(18+2)\div 2=10$, or 1-and-11, which would give a progressive, double, doubly re-entrant winding. In Fig. 3 the series of P coils starts on bar *1*, goes through coil *A*, to bar *9*, to coil *i*, then to bar *17*, which is two bars behind the one started on. Note that the heavy lines represent one winding, the bars being marked by shading lines. Continuing the series, we go from bar *17* to coil *q*, to bar *7*, coil *g* to bar *15*, coil *o*, to bar *5*, coil *e*, to bar *13*, coil *m*, to bar *3*, coil *c*, to bar *11*, coil *k*, and thence to bar *1*, or the winding closes on itself after passing once around the armature and through half of the coils. In this case the winding touches only the odd-numbered bars. The second winding starts at bar *2*, and proceeds around the armature to bars *10*, *18*, *8*, *16*, *6*, *14*, *4*, *12*, and back to bar *2*. Two separate windings are thus formed. With a brush in contact with bars *1* and *2*, and also bars *5* and *6*, a four-circuit winding would be indicated.

Fig. 4 shows a four-pole, retrogressive, wave winding having four circuits, singly re-entrant, with 20 bars and slots, coil pitch 1-and-6, lead pitch 1-and-10. Note that this

(*Please turn to page 604*)

Figs. 3 and 4—At the left is a four-circuit, four-pole wave winding that is retrogressive (short pitch) and doubly re-entrant, as indicated by the lead pitch in bars being an even number (8). At the right is a four-circuit, four-pole wave winding that is retrogressive (short pitch) and singly re-entrant, as indicated by the lead pitch in bars being an odd number (9).



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Chicago, December, 1925

The Best Safeguard Is a Careful Man

MEN engaged in safety work in industrial plants generally estimate that it is possible to safeguard against approximately 90 per cent of industrial accidents; for the other 10 per cent the worker alone is responsible. This would indicate that safeguarding alone is not adequate, and that the men must be trained so that they will not only take full advantage of the safeguards and not remove them or evade them, but, in addition, will do their work carefully so as not to endanger themselves or their fellow workers.

The necessity of safeguarding workers by teaching them the careful way to do their work is particularly apparent in the case of men who are engaged in maintenance and operation. These men often find it necessary to remove guards to get at machines for repair or other work in which they may be endangered by the accidental starting of the machine and, in general, they are frequently exposed to unusual hazards.

Foremen in charge of such work should always watch a new man to see whether he is inclined to be careful or reckless in performing dangerous tasks. If he neglects to take the necessary precautions or is otherwise careless, the foreman should show him the safe way to do the work and insist that he practice it.

In no department of an industrial plant is the axiom, "The best safeguard is a careful man," more true than in the maintenance and operating departments.

Healthful Workrooms Make for Efficiency

WORKING conditions in many industrial plants are not always ideal. However, the fact that noteworthy advancements in industrial sanitation and hygiene have been made during the past few years is well shown by the changed attitude of insurance companies toward workers in occupations that were formerly considered hazardous. For example, textile workers were steadfastly refused insurance because the dust was considered to be injurious, and a high death rate from tuberculosis existed among them. In fact, this class was about the last to be exempt from special rating even when accepted. Now the entire force of men and women, of all ages, in big textile plants is being accepted under group insurance.

An investigation made by the Prudential Insurance Company in connection with its group insurance shows that the majority of plants are conscientiously co-operating with health departments and have installed the most modern and effective devices so far produced to protect their workers from the dangers of dust, fumes and gases. Engineering science has been so successful in perfecting mechanical ventilation that there need be little difficulty in finding the proper equipment to meet any particular need.

Poisoned or even devitalized air is now recognized as a fundamental cause of loss to the employer and danger to the employee. Several states have laws requiring exhaust hoods on all machines for the buffing, polishing or grinding of metal, so as to carry away all dust given off in the process.

In the matter of providing exhausts for the removal of noxious fumes and gases, considerable advancement has also been made. Many states have standard regulations for the proper ventilation of factory buildings. For instance, New Jersey has a code of sanitary and industrial engineering standards and all manufacturers and contractors have to file definite engineering plans for the ventilation apparatus before the installations can be made. Window ventilation is not sufficient in workrooms where processes require the use of volatile, poisonous preparations or chemicals. The aim now is to confine vapors and dust at the point of origin, and to remove them to the outer air in such manner as to prevent them from contaminating the air of workrooms.

Apart from humanitarian considerations, money spent for equipment that will conserve the health and increase the efficiency of employees, may be considered to have been put into a gilt-edge investment.

Makeshifts Are Not Intended for Permanent Use

OFTENTIMES the practical man takes pride in pointing out some makeshift of his devising that has served its purpose well. This feeling of pride is, no doubt, frequently justified by the results obtained or the purpose served. However, it does not pay to overlook the fact that in an emergency, when it is of the utmost importance to keep the wheels turning, it may be necessary to make use of devices or expedients that are not worthy of a permanent place in an installation of equipment. Even though such makeshifts have rendered good service, it is seldom advisable to leave them in operation after the emergency is past, or longer than is necessary to secure standard equipment with which to replace them.

By their very nature, makeshifts cannot, as a rule, be expected to have, nor do they have, the same reliability and efficiency that are built into the equipment put out by a reputable manufacturer. He has at his command designing skill and manufacturing facilities

that no maintenance department or repair shop can hope to equal.

Makeshifts should be considered only in the light and for the purpose for which they are intended: temporary use until they can be replaced with standard equipment. In any industrial plant continuity of production is too important to be jeopardized by the false economy that will permit a poorly-designed and clumsily-built device to take the place of equipment that has proved its worth under the searching test of service.

Do You Need More Lighting Units or Cleaner Reflectors?

THE shortest days of the year are now with us, and it is at this time that the plant lighting system is used most intensively. It has been proven times without number that an investment in adequate plant illumination pays large returns. Yet, are we always getting all that we should from our investment in artificial illumination?

The first requisite of adequate illumination is that there be a sufficient number of lighting units, properly placed. The next requirement is that the light be directed towards the working space; in other words that the least possible amount of light be wasted. It is for this reason that we have reflectors. But the usefulness of a reflector is easily and rapidly lost through the accumulation of dirt upon it. There are undoubtedly thousands of high-grade reflectors rotting away with dirt and rust, without performing the work for which they were purchased.

Approximately 50 per cent of the cost of an industrial lighting unit is in the reflector. Reliable tests on typical installations show that on an average the loss of light when reflectors are not regularly cleaned amounts to nearly 50 per cent of that available when cleaning is done systematically. In other words, half of the investment in a lighting unit produces half of the light.

Failure to clean the reflecting units periodically, results in a waste of not only half of the investment in lighting equipment but also in a loss of half of the light that is actually available.

Complete Data Make It Easier to Answer Questions

MANY delays are occasioned and much time is lost unnecessarily by failure of those who are seeking information on equipment, particularly electrical equipment, to give all of the data needed before an intelligent answer can be given. Manufacturers of industrial equipment, and others who are in position to give advice, are frequently called upon for information which they would be glad to give, but in many instances the data sent are so incomplete that it is very difficult or impossible to give an answer that is anything more than a guess, which is just about as likely to be wrong as correct. Under such circumstances it is necessary to write for additional information. This is not only annoying, but it is a needless waste of effort on the part of everyone concerned.

Thirty years or so ago, when there were comparatively few manufacturers of electrical equipment, and each one produced at the most only a few items, the terms "three-phase motor," "transformer," and so on, meant much more than they do now, when there are scores of manufacturers producing widely varied lines of standard and special equipment designed to operate under many different conditions.

To the manufacturer of a piece of equipment, the data given on the nameplate thereof serves to identify it completely. The nameplate is a key to the essential features of the design and operating characteristics of the device in question.

You will make it much easier for the other fellow to answer your questions or give you advice on any equipment, if you will send him all of the nameplate data, together with any information regarding operating conditions which is necessary to a thorough understanding of the situation.

You Can't Lift Yourself by Your Boot Straps

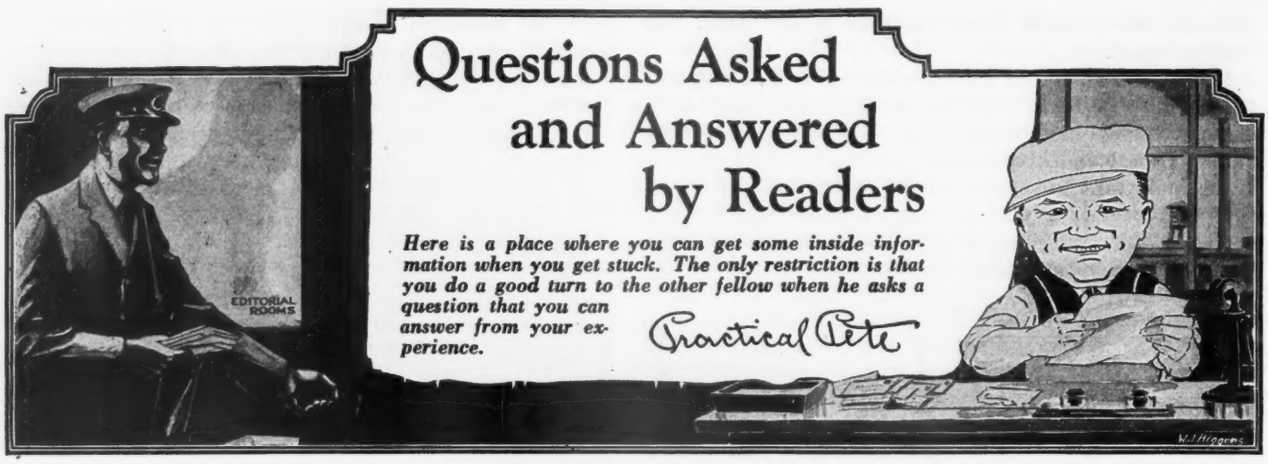
TRUE executives realize that they can climb higher and easier in their organization through the boosts and co-operation of their subordinates than by treading rough-shod over them. Without the whole-hearted co-operation of his men, particularly of his assistants, the man at the head of a department usually has to drag them along with him, instead of receiving an enthusiastic push from them. In other words he is trying to lift himself by his boot straps.

Executives who do not receive a boost from their associates can usually look to themselves for the cause, which most generally is due to a selfish desire to "hog" all of the glory, or to a reluctance to commend a subordinate for work well done. Of these, the former generally causes the more discontent because the superior then usually appropriates as his own the ideas and suggestions of others without crediting the source. Private words of commendation can never compensate for the withholding of public credit for an idea or an accomplishment.

Any fair-minded executive knows that he would think it unfair if *he* were treated that way. His subordinates want to advance also, if he be promoted. Unless a subordinate has received credit from time to time for his accomplishments he is less likely to be considered when an opportunity for advancement opens, and altogether too often an outside man is brought in who frequently has less ability and much less interest in and knowledge of the plant than the old employee. After such an experience it is difficult to get men to co-operate whole-heartedly and offer suggestions and advice freely.

These statements apply not only to the head of a department and his actions toward his subordinates, but as well to the subordinates and those under their direction, and clear down to the man on the job with a helper. Every man appreciates receiving credit for what he does. The leader who gives credit for tasks well done will soon find his men willing to help him, which not only makes it easier for him to advance but builds morale—the stimulant of a successful organization.

Any executive who has the co-operation and support of his subordinates will soon find that he has got a good start on the path to advancement.


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete
W. I. Higgins

Who Can Answer These?

Ramp for Industrial Truck.—The basement floor of one of our buildings is 4 ft. below the grade level. We are planning on installing an electric storage battery truck for handling heavy material out of this basement and from the yard up to the first floor. What grade should be given to the incline or ramp? Would it be advisable to roughen or ridge the surface of the concrete to give the truck better footing? Part of the ramp will be outside, and exposed to the weather.
Peoria, Ill. S. L. G.

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What Shop Equipment Will Be Required Here?—I would like to have some of our readers tell me what equipment they think will be necessary for a shop to handle a general motor repair business in a city having a population of 50,000. I wish to have as completely equipped a shop as is consistent with the amount of repair work that I may expect to do in a city of this size. Any recommendations as to kinds and makes of equipment necessary will be very much appreciated. Also, I should like to know what kinds and amounts of supplies, such as insulated wire, insulation, varnishes, tapes, etc., should be carried in stock.
Pedro Miguel, Canal Zone. P. F. W.

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Misleading Results Sometimes Obtained from Magneto Test.—Sometimes I get rather misleading results through the use of a magneto to determine whether there are defects in some of our electrical apparatus. Under certain conditions I have found that the magneto will indicate a dead ground, whereas further investigation shows that the equipment is in very good operating condition. Also, I have found that a magneto will sometimes indicate an open in a shunt-field coil, when further investigation shows that the field coil is O. K. I should like to know if any readers have had similar experiences and can explain the reasons for this peculiar action of the magneto. Also, can you suggest other test methods that might be used under the conditions mentioned?
Omaha, Neb. M. P.

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Is This Lamp Consumption Too High?—Our plant is a malleable iron foundry and our lights are operated from 230-volt direct-current power supply. During the first 314 days of this year, we used a total of 972 lamps in 847 outlets, making an average consumption of 1.33 lamps per outlet per year. To be specific, we used 230, 100-watt type C lamps in 275 outlets, or 0.97 lamps per outlet per year. We used 162, 200-watt type C lamps in 160 outlets, or 1.18 lamps per outlet per year. For portables and extensions at molders' benches we used 600, 50-watt, mill-type lamps in 412 outlets, or 1.7 lamps per outlet per year. The large lamps are subjected to slight vibration due to machinery and lineshafting. The lamps burn 9½ to 10 hr. per day. I should like to know whether other readers think that our average lamp consumption is too high. Also I shall appreciate any information regarding lamp consumption in plants having conditions similar to a foundry, as well as in other types of manufacturing plants.
Chicago, Ill. W. A. B.

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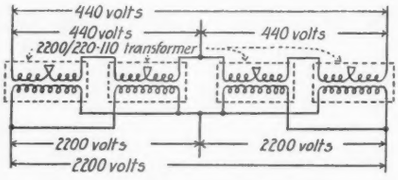
What Is the Capacity of this Transformer Bank?—I have four 25-kva., 2,200/220/110-volt transformers connected to a three-phase, 2,200-volt, power supply as is shown in the accompanying diagram. The secondary of each transformer is so connected that the two 110-volt windings are in series to supply 220 volts. As can be seen from the diagram, 440-volt, three-phase power is obtained from the secondary of this bank of



transformers. I shall greatly appreciate it if some reader will tell me what the capacity of this bank of transformers is with the connection that I am using. I should also like to know the safe secondary line current and also the safe primary line current that these transformers will take with this connection.
Hattiesburg, Miss. J. M. M.

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What Is the Best Type of Drive for This Installation?—I should like to have the advice of readers on the following problem. We wish to operate by a 10-hp., 1,150-r.p.m. motor, a small machine shop and a small reciprocating pump, which are in different rooms, separated by an 8-in. brick wall. We wish to place the motor in the room with the pump. There are three possible drives. (1) Mount the motor on the floor or wall and use a short, overhead lineshaft with three pulleys, one for the motor belt, one for driving the pump and the other for driving the machine shop. (2) Mount the motor on the ceiling and connect it directly to a short lineshaft with two pulleys, one for the pump and one for the machine shop. (3) Mount the motor on the floor and drive the pump directly through a speed reducer. In this case I would use between the motor and the speed reducer a short piece of shaft on which would be mounted a pulley driving an overhead shaft, which in turn would be belted to the machine shop lineshaft. Will someone please tell me which of these combinations would be best from the standpoints of cost, maintenance and operating advantages? Do you know of a better type of drive than I have outlined?
Chicago, Ill. O. H. E.

Answers Received To Questions Asked

Where Does a Lineshaft Usually Break?—Recently a 4 3/16-in. shaft broke underneath the hub of a 36-in. pulley sheave carrying eight 1 1/4-in. ropes. Several millwrights have told me that a lineshaft always breaks in the hub of the pulley, but none of them could tell me why. I should like to know if other readers have had a similar experience and if they can give any explanation of why the shaft breaks in this location. I am anxious to avoid a repetition of this trouble, if possible.
Chicago, Ill. R. C. M.

Answering R. C. M.'s question, a lineshaft, like a chain, usually breaks at its weakest link. In this case the weak spot of the shaft is in the hub of the sheave or pulley due to having the bearings too far away from the sheave. With a heavy pull at this point the continual bending of the shaft eventually breaks it.
Master Mechanic, H. H. LANGBEHN.
Port Vegetable Oil Mills,
Portland, Ore.

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In reply to R. C. M. I would say that the greatest stress always comes at the hub of a pulley on account of the pull on the shaft. Also, the shaft always has a certain amount of vibration the continuance of which will cause the shaft to crystallize and break next to the hub of the pulley, as the hub is solid and will not give. There is a certain amount of give in the bearings and to eliminate further breaking of the shaft place the bearings as close to the hub of the pulley as practicable.
Chief Electrician, E. N. DILLARD.
Booth Kelly Co.,
Springfield, Ore.

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Replying to R. C. M., a shaft may break underneath the hub for the following reasons:

(1) The torsion or twist due to the load is concentrated at that point, or in other words it is subjected at that point to probably the greatest stress. It may, therefore, fail due to a gradual breaking down at that point.

(2) If the shaft has a keyway at the point where the pulley is attached, its section is reduced, so that if it is not correctly designed for the load carried, it may fail from this cause. (3) The question does not state how the

pulley was mounted or attached to the shaft. If the shaft has a section turned off for a pulley with a fillet on one or both sides of the pulley section, the turning of the shoulder may result in a weak section which will eventually break.

On the other hand, shafts have been broken due to crystallization at a hanger due to pounding when hangers were out of line. Careful design and installation will eliminate most shaft troubles.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

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Referring to R. C. M.'s inquiry, an explanation in simple terms would be that a shaft breaks in the loaded pulley, first, because the pull of the belt or ropes produces the greatest bending there, just as a man breaks a stick over his knee; second, because at that point there is usually a keyway to weaken the shaft and provide a sharp corner from which to start a crack; and, third, because, with the turning of the shaft there is with every revolution a back-and-forth bending action which eventually, if the pull is at all heavy, causes crystallization, or fatigue of the metal, which may eventually result in a break.

One might think that the pulley hub has sufficient reinforcing effect to stiffen the shaft and cause the break to come at one side, and occasionally it does. However, in practically all cases where split pulleys are used there is give enough in the bolts to allow the shaft to deflect to some extent inside the pulley hub, and most solid pulley hubs have sufficient clearance for slipping on the pulley while the metal in the hub is light enough and compressible enough in the bore to permit considerable bending.

We have had several breakages of this sort, but as the belts were not unduly tight and the shafts were of ample size for the horsepower carried at the speed we were inclined to suspect that the material of the shafts was not adapted to cold rolling and that a certain amount of crystallization or an incipient flaw existed when the shaft was installed and gradually developed in operation. On replacing the defective shafting with shafting from another source, no such trouble has recurred. H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

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Referring to R. C. M.'s question, a lineshaft usually breaks where the stresses on it become greater than its strength to resist them. In the case R. C. M. cites, the shaft is too small in diameter or the bearings supporting it on each side of the pulley are too far away. The center line of the pulley is the point of greatest bending moment and the stresses set up in it at this point are due to deflection rather than torsion. These stresses, which are apparently above the safe limit, are alternately tensile and compressive in each revolution of the shaft, so that in a short time the strength of the metal is reduced.

In order to avoid a repetition of your trouble, move the present bearings or provide bearings closer to the pulley. Another alternative is to bore out the hub of the pulley and install a larger shaft at the place where it passes through the hub. The larger shaft may be turned down for the bearings since they have not given you trouble. The amount of increase necessary in the shaft diameter will depend on the distance between bearing centers and the outside diameter of the pulley hub, which information is not given in the inquiry. W. A. PLANT.
Power House Foreman,
Mattagami Pulp & Paper Co.
Smooth Rock Falls, Ont., Can.

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R. C. M. asks if readers can explain why shafting breaks at the hubs of pulleys. He describes the breakage of a 4 7/16-in. shaft under the hub of a 36-in. sheave carrying eight 1½-in. ropes which, by the way, is a rather small sheave for that size rope.

It would be surprising if a shaft broke anywhere but at the pulley; this is the point of maximum bending moment, and is usually weakened by a keyway. At a speed of 200 r.p.m. a 4 7/16-in. shaft is capable of transmitting more than 200 hp., and the eight 1¼-in. ropes about 90 hp.; so it seems that the shaft in this case is amply strong for the service. It is, therefore, hard to say just what caused the break, assuming, of course, that the distance between bearings is not so great as to cause an abnormal bending stress. Whether the shaft failed by fatigue or because of defective material, can best be answered by R. C. M. as he has the shaft, and probably its history, available for investigation.
Los Angeles, Cal. C. O. SANDSTROM.

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Referring to the problem by R. C. M., the shaft broke in the hub of a pulley which was either pressed on or was clamped tightly on the shaft. Probably the most common reason for breaking at this point is the vibration of the shaft. The rate of vibration changes at the heavy wheel hub, which cannot vibrate at the same speed or direction as the shaft. This causes crystallization in the steel and in time it breaks.

Another cause is the stress set up by the torque on the lineshaft. The shaft when under load twists to some extent but an enlarged place or hub pressed on acts to stop the twisting at that point. This may cause considerable working of the steel at that point, and the result is the same as stated above.

The breaking of shafts is very noticeable where wheels are pressed on, as for instance car wheels. Almost invariably a car axle breaks close to the wheel, and on electric cars the axle, which carries the motor and gear, gives the most trouble. For this reason, these axles are usually enlarged for the gear and wheel fits in order to help overcome the trouble.

Breaking from this cause starts on the outside and works to the center, but not in a circle, as the harder parts of the axle will break down first.
Longview, Wash. C. L. HARTMAN.

What Is Wrong with the Method of Rewinding This Armature?—I have a Willey electric drill, serial No. 20063, 110 volts, a. c., 6 amp., Type 4 U. C. 2, which is manufactured by the James Clark, Jr., Electric Co., Louisville, Ky. The armature has 17 slots and 32 bars, and is wound with No. 23 cotton-covered enameled wire, using 13 turns per section, with a coil span of 1 to 8, and the leads checking straight out. The armature is hand-wound, left-handed, with the commutator to the right. The only change was that I rewound it right-handed instead of left-handed. I expected that the motor would reverse its direction, which it did. When the drill was connected to the line, both brushes sparked badly, which convinced me that they were off their neutral position. I moved the brush holder to different positions around the commutator, but could not find the neutral point. I took the brush holder head off and checked the leads, which were O. K. Finally the armature was stripped and rewound the same way as before except that I changed the span of the coil from 1 to 8 to 1 to 9. Without moving the brush holders from the position set at the factory, the drill operated perfectly. Why would this armature not operate with the coil span 1 to 8 and wound right-handed? Would winding this armature right-handed instead of left-handed have any effect besides reversing rotation?
Richmond, Va. H. F. S.

In reply to H. F. S.'s question, when the direction of rotation of a universal motor with a compensated winding is reversed, the polarity of the compensating winding should at the same time also be reversed.

The polarity of the compensating winding should be the same as the main field adjacent to it against the direction of rotation.

The above explains the reason for not being able to find a brush position that would give sparkless operation, with the reversed winding.
Wilkinsburg, Pa. A. C. ROE.

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In answering the question by H. F. S., I would say that all of our small armatures are machine-wound. It is much easier and better for us, with our equipment, to wind the armatures with the commutator on the right side, the wire being put on left-handed or counter-clockwise. If an armature were rewound right-handed or clockwise and connected up the same as originally, the only change, if everything else about the motor is the same as it was originally, would be to reverse the direction of rotation. To counteract this effect and make the motor operate in the same direction as before it is only necessary to reverse the brush leads or, if the motor is so arranged, the whole brush mechanism could be rocked half-way around and the motor would reverse. According to the information received, this was done and the motor sparked in any position. Such being the case, we are led to believe that there was something wrong somewhere, aside from the manner in which this armature was rewound.

Stripping the armature and rewinding in slots 1 and 9 instead of 1 and 8, and winding right-handed instead of left-handed, brings the leads out in the same position as if the armature had been wound left-handed, 1-and-8. Since the number of slots in the armature is 17, winding it 1-and-8 brings the leads one slot this side of 17, as 2 times 8=16; a span of 1-and-9 brings it one slot on the other side of 17, as 2 times 9 = 18. Winding it right-handed

reverses this condition and winding it 1-and-9 reverses it again, which brings it back to the original condition.

The writer is assuming that when the armature was stripped and wound 1-and-9 instead of 1-and-8, it was wound right-handed, the same as when he wound it in the beginning.

President J. A. CLARK, JR.
James Clark Jr. Electric Co.,
Louisville, Ky.

* * * *

There is nothing wrong with the method of winding the armature, as explained in the question asked by H. F. S. Changing from a left-hand throw to a right-hand throw would give a reverse direction of rotation, as well as a reverse direction of current through the armature. On this type of motor a compensated winding is used to produce a magnetic flux which will oppose the magnetic flux produced by the alternating current in the armature. If the flux produced by the alternating current in the armature is not neutralized, it will induce a current in the coils under commutation, causing sparking.

In this case the flux produced by the alternating current in the armature is reversed, due to changing the winding from a left-hand to a right-hand throw. Therefore, the flux produced by the alternating current in the armature being reversed will add to the flux produced by the compensated winding. Had the compensating winding been reversed, the motor would have operated without sparking.

When the armature was rewound, the change to a span of 1-to-9 instead of a span of 1-to-8 did not affect the commutation of the motor so long as the coil had a left-hand throw. This permitted the flux produced by the compensating winding to neutralize the flux produced in the armature.

J. M. ZIMMERMANN.
Renewal Parts Engineer,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

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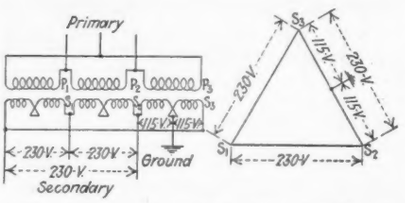
How Should a Delta-Connected Transformer Bank be Grounded?—I should like to know some of the standard or practical methods of grounding a delta-delta connected bank of transformers. We have a transformer bank consisting of three single-phase, 13,200/440-volt transformers, which are delta connected on both the high- and low-tension sides. Now I get a reading of about 100 volts from each 440-volt bus to ground. Consequently, I am planning to ground the low-tension side of the transformer bank. Can some reader tell me to what part of the low-tension delta I should connect my ground or what reactors or other devices I must use to obtain my ground connection?

Omaha, Neb. G. C. B.

The accompanying diagram will show G. C. B. how a delta-connected bank of transformers may be grounded. As may be seen, the middle point of any one transformer in the delta-connected bank may be permanently connected to ground to form the ground connection.

Before grounding the transformer as shown in the diagram, all of the circuits that originate from this bank of transformers should be tested for any accidental grounds that may already exist on them. It is best to eliminate any grounds that may be found.



Here is one method of grounding a delta-connected transformer bank.

In case it is necessary to operate a delta-connected transformer bank in open delta, the grounded transformer should not be the one that is cut out. If it is necessary to cut out the grounded transformer, the ground connection should be moved to one of the other transformers.

When a secondary circuit is permanently grounded as is shown in the accompanying diagram, all meters on the secondary side should be checked and the current coil or coils on the meters transferred to the ungrounded lines. This is important and care must be exercised to see that it is done.

HARRY J. ACHEE.
Chief City Electrician,
Woodward, Oklahoma.

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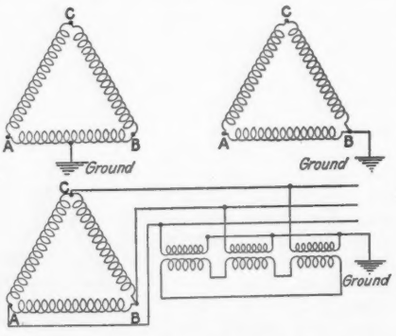
In reply to G. C. B.'s question in a recent issue, the delta-delta connected transformer bank may be grounded on the low-voltage side in a number of ways. The accompanying illustration shows the low-voltage delta and three methods of grounding it that are in common use.

The upper left-hand sketch shows a method of grounding at the middle point of one of the windings. Although this method is often used, it has the objection that while the voltage from lines *B* and *C* is only one-half of 440, or 220 volts, the voltage from line *A* to ground is 381 volts.

The upper right-hand diagram shows a method wherein one of the lines is grounded. This method gives full line voltage to ground from lines *A* and *C*.

In the lower diagram is shown a method of grounding in which three small transformers are star-connected to the three lines, *A*, *B*, and *C*, with the grounded neutral on the 440-volt side and connected in closed delta on the other side. With this method it is not absolutely necessary that the star-connected side be a 381-volt winding, as the same effect will be obtained if a higher voltage winding is used.



Three methods of grounding a delta-connected transformer bank.

Of these, the method shown in the bottom diagram is to be preferred. The second best connection is shown at the upper left.

This method is to be preferred if the expense of the grounding transformers can be justified, since it gives a balanced voltage to ground on all lines.

The method shown at the upper left-hand corner of the diagram is the second best method of grounding, but requires a tap at the middle point of one of the windings. The method shown at the upper right-hand corner of the diagram, should not be used unless either or both of the others are out of the question, for it gives line voltage to ground for two of the lines, *A* and *C*, and a ground on either line would probably give more trouble than would be encountered with either of the other two methods.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

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In reply to the question asked by G. C. B., one standard method of grounding is to connect the middle point of one of the transformers to ground, as shown in Fig. 1. If there are no middle taps on the transformers, then one corner of the delta, that is, one line wire, must be grounded.

When grounding a transformer bank,

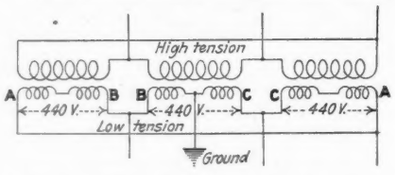


Fig. 1—The middle tap of one transformer in a delta-connected bank may be used as the grounding point.

as shown in Fig. 1, it should be noted that the voltage from two of the line wires to ground will be 220 volts and from the remaining line wire to ground will be 381 volts. This is clearly illustrated in the left-hand diagram shown in Fig. 2. In this diagram the middle tap of transformer *BC* is grounded. Hence the potential from point *B* or *C* to ground will be 220 volts, while the potential of *A* will be 381 volts above ground potential. The right-hand diagram in Fig. 2 illustrates the conditions that exist when the delta is not grounded. In this case the stress to ground is the same from each line wire, being 254 volts. Inasmuch as the insulation of one wire is under a 381-volt strain to ground, more motor insulation failures are likely to occur with a grounded secondary installation of this kind.

If other banks of transformers are operated in parallel with the grounded bank, care must be taken to see that all banks are grounded in the same place; that is, if transformer *BC* is grounded in the first installation, all succeeding installations must likewise have the transformer *BC* grounded. This is to prevent short-circuiting part of a transformer winding.

One advantage of the grounded secondary system is that it prevents trouble from capacity effects. A person coming in contact with a wire of an ungrounded system may receive a

shock, due to the capacity effect between the high- and low-tension windings of the transformer. The higher the primary voltage of the transformer

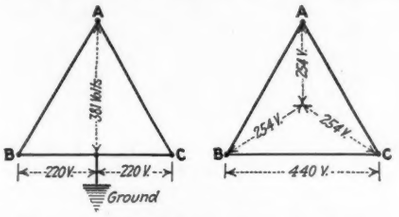


Fig. 2—Grounding of the middle point of a transformer gives an unequal voltage stress to ground on the three line wires.

As shown at the left, lines *B* and *C* have a potential to ground of 220 volts, while line *A* has a potential of 381 volts to ground. Voltage stresses to ground on an ungrounded delta-connected bank are equal, as is shown in diagram at right.

and the larger the system, the greater will be the condenser or capacity effect.

Installation of reactors or other devices in the ground circuit is not to be recommended as this may interfere with the correct operation of protective devices.

L. P. STAUBITZ.
Chief Electrician,
LaClede Steel Co.,
Alton, Ill.

* * * *

What Causes These Brushes to Chatter?—I have a three-phase, 440-volt, 75-hp., slip-ring motor which is giving trouble from chattering of the brushes. Everything that I know of has been tried to prevent this, but without success. The brushes will stop chattering immediately after the slip rings are sanded slightly while the machine is in operation, but after several hours they begin to chatter again. I shall apreciate it very much if some of the readers of INDUSTRIAL ENGINEER will tell me how I can overcome this trouble.

Los Angeles, Calif. F. P. B.

Replying to F. P. B., try changing the angle of the brushes. This is often an important factor.

I recall an engine-driven generator I had that would develop brush trouble once in a while, and I found no positive relief for this other than to take the rings off, turn them down and polish at high speed. This would end the trouble until a new brush was needed ,and particular care had to be exercised to rid the ring of the slightest sparking or it would immediately develop into serious arcing. I found temporary relief through the use of a little vaseline on this particular machine; this is one way of preventing chatter, and is sometimes sufficient.

Particular care must be exercised in fitting brushes to such temperamental rings; I have found it advantageous to smooth off both the toe and heel of such brushes.

Having brushholders too far removed from the ring is often the cause of chattering and is an inducement in all cases. Brushes that are too loose in their holders, with too little tension, have a tendency to chatter and brushes that are too narrow to carry the current or have a tendency to run off the ring may begin with a sparking that will develop into chattering with bad arcing.

I have found sanding to be of little value in stopping a brush from chattering, and the effect lasts about as long as an application of vaseline. Where vaseline has a noticeable value a change of brushes will generally correct the trouble.

Without making recommendations as to its use or its value, I have corrected slight chattering with the use of a soft lead pencil while the machine was in operation. It is effective for obvious reasons, but is not recommended as a "cure-all."

EDWARD JAMES.
Newark, N. J.

* * * *

Answering F. P. B., it is assumed that the machine did at one time operate satisfactorily. Chattering of the brushes may be due to several causes, such as worn bearings, worn shaft, bent shaft, variable load with more or less shock, very heavy starting load and so on. Anything that will cause a movement between the slip rings and the brushes radially will have to be eliminated. See that the brush holder is quick acting; that is, that the brushes can follow any slight movement of the slip rings. Also, make sure that the slip rings are tight to the shaft, that the rings run true, and that the brushes move freely in the holders.

The springs may have taken a set and will need replacement. If correcting according to the above suggestions does not eliminate the trouble, it may be that the slip rings have some spots that are softer than others and wear faster. The brushes should be able to carry their load easily and should be of a low resistance with sufficient lubricating material in them to prevent cutting.

C. N. SHAFER.
Supt. Service Division,
The Lincoln Electric Co.
Cleveland, Ohio.

* * * *

In a recent issue, F. B. P., mentions the trouble he is having with brushes chattering. The rings have evidently become worn out of round due to natural wear, or because the motor bearings are slightly worn. Sometimes an armature shaft becomes sprung, causing the brushes to vibrate or chatter badly.

We have had numerous cases of this kind and to remedy the trouble, generally take the rotor out and turn the rings down in the lathe.

However, some motors cannot be shut down long enough for this purpose; so we use a home-made tool for truing up the rings. This tool was made by grinding the end of old file square and making the edge as sharp as possible. When truing up the rings the motor is run up to full speed and the sharp cutting edge of the file held firmly against the rings (one at a time, of course) until they are reasonably true. It is surprising how true the rings can be made in this way. We have in this way stopped chattering that had continued for 18 months or more. When the rotors were at length taken out, it was generally for some other reason.

It is advisable to give the rings a good sanding down with sandpaper after they have been trued with the file.

GEORGE D. RINGNESS.
Peoria, Ill.

In reply to the question by F. P. B. I think that the chattering is caused by the collector rings and brush surfaces being unevenly hard; possibly the rings have small, flat spots that are not easily detected.

I would recommend that the rings be turned or ground true and smooth. Then use a medium soft brush (with shunts attached) well fitted to the holder. The springs should press firmly against the brushes.

Often we find that the shunts will become loose on the brushes, thus allowing the springs to carry most of the current. This heats and weakens the springs and starts trouble.

WILLIAM J. MILDON.
Supt. Power and Equipment,
Madeira-Hill Coal Mining Co.,
Philipsburg, Pa.

* * * *

Referring to F. P. B.'s question, I believe that your brushes are too hard for slip-ring service and the reason they stop chattering immediately after sanding the rings is that the sanding removes the roughness that the brushes have cut into the rings.

Of course, there are other causes of chattering: the usual cause is that the brush is too small for the box or holder. Vibration will cause chattering, as will also eccentric or pitted rings. However, I do not believe that a slight sanding would stop or prevent chattering if it were caused by any condition other than excessive hardness of the brushes which will make the rings rough, as mentioned above, and thus cause the brushes to chatter.

I presume that the rings are brass or bronze and I would recommend using grade No. 414 or No. 539 brushes, manufactured by the National Carbon Company.

GRADY H. EMERSON.
Asst. Chief Electrician,
Alabama Fuel & Iron Co.,
Acmar, Ala.

* * * *

Mounting Motors on Ceiling—In order to get more free floor space we are planning on mounting the motors on the ceiling, above the machines and line-shafts which they drive. I should like to have the experiences of other readers on the following points: (1) The best method of attaching motors to concrete ceilings. (2) What is the best and simplest method of raising and holding motors up until they can be attached? (3) Is there likely to be any more trouble with motors so mounted, than when they are placed on the floor?

St. Louis, Mo. E. H. G.

In reply to the question by E. H. G., I wish to suggest the following: Drill four holes in the ceiling to correspond with those on your motor. Countersink the holes on the floor above to accommodate the heads of the bolts, and a large washer. From the floor above, drop a steel cable through two of the diagonally opposite holes drilled in the floor. Place the motor on a platform to raise it off the floor about 4 ft. This is done to lessen the distance through which the motor will have to be raised, and thus make it possible for the hoist to lift it up to the ceiling. The motor should be placed with the base turned up. Insert one end of the cable in one of the holes in the motor base and the other in the hole diagonally opposite, and clamp the ends fast. Attach a hoist on the floor above, hook the cable

to it and pull the motor up flush with the ceiling. Now, drop two bolts of the proper length and size in the two vacant holes in the motor base and draw them tight. These bolts will hold the motor until the cable can be removed and replaced by the other bolts.

Make sure that the oil wells are turned to the proper position and you will not have any trouble with motors so mounted.

Jersey City, N. J. B. DOWICK.

* * * *

With reference to the question asked by E. H. G., you will not have any more trouble with motors mounted on the ceiling than when placed on the floor, providing that you give them as much attention on the ceiling as you did on the floor. On the ceiling they are up out of the way, and not so easy to get to.

Motors may be bolted to a frame or base made of 4-in. by 6-in. timbers. If necessary these timbers may be bolted to the ceiling by bolts through the floor above, or through the roof.

Almost all new buildings now have cast-iron inserts in the ceiling for the purpose of bolting timbers to them for mounting motors and other equipment. Do not try to use anchors of any kind to hold motors on the ceiling; there is always danger of them coming loose and causing trouble.

Run bolts all the way through the ceiling to the next floor or roof. My motors are mounted this way and I have not had any trouble with any of them coming loose. On the other hand, I have had plenty of trouble with anchors.

If the ceiling is wood it will be all right to use lagscrews for supporting the motor. As to the equipment for raising the motors, I would suggest that you get a Revolvator, made by The Revolvator Co., Jersey City, N. J. This will put up and take down all the motors you can handle.

Indianapolis, Ind. H. F. FOX.

* * * *

Answering E. H. G.'s question, in modern factory buildings it is now customary to have mushroom anchors set in on definite center distances at the time the building is erected, so that you can readily fasten up cross-members to which you can attach your motors, or rails or motor supports.

Motors can also be fastened up by cutting holes through the ceiling. Holes in the floors above should be countersunk deep enough to sink the heads of the bolts flush with the surface and when the motor is in place fill around the bolt heads with cement grout. If the motors are on the ceiling under the roof, you should provide bosses on the roof and cover these with caps to keep out water. These raised bosses should, of course, be flashed to the roofing so that they will be water- and weatherproof.

Motors can be raised by the aid of portable stock tiering or hoisting elevators, or by putting the ends of a wire cable down through two diagonal holes which have been cut for supporting the motor or its mounting and then through the corresponding holes in the motor or motor supports and placing clamps on the cable ends so they will not slide or let the motor drop down.

If the motor has rails it should be bolted to, and lifted by, the rails. Be sure that you have enough hoisting range so that you can lift your motor all the way. If not, provide blocking so that you can hold your motor and get another lift on it by taking the slack out of the cable. When the motor is pulled up, place the nuts on the two free bolts and then remove the cables and drop the last two bolts in place and tighten them up. Be sure to provide locknuts on all holding bolts so that if they should tend to vibrate loose, the motor will not drop.

With the same maintenance you should have no more trouble with motors on the ceiling than on the floor. However, it will as a rule be warmer next to the ceiling, so that the same load will cause a somewhat higher operating temperature. C. N. SHAFER.

Supt. Service Division,
The Lincoln Electric Co.,
Cleveland, Ohio.

* * * *

My advice to E. H. G., about placing his motors on the ceiling, is: Don't do it. If you desire to take them off the floor, which is commendable in utilizing floor space, do not go to the other extreme and place them against the ceiling; or at least before the change is made, visit some shop in which they are so located and try to look into the motors. Make a casual examination of their condition and at the same time try to ascertain whether you could give the motors better maintenance than the electrician who has charge of it.

To emphasize this, I might add that I recently completed an inspection of several such installations and in some cases it was next to impossible to make brush changes, let alone try to have 100 per cent maintenance, with the result that good motors are being sacrificed, with enough competent men available to keep them in good condition, if they could only reach them so as to make a worthwhile inspection of their condition.

I do not mean to imply that motors should not be taken off the floor, but do not put them on the ceiling. Put them on a platform that is far enough below the ceiling to permit the motors to receive as good maintenance as they could get on the floor. They will not receive this unless a competent chief checks up on his maintenance crew often, for this type of installation was the example for the saying, "Out of sight, out of mind."

If motors are mounted on a platform, a tackle can be used for raising and lowering them, and no more trouble will be experienced with this method of installation than would be encountered with floor mounting, providing that a rigid platform is used.

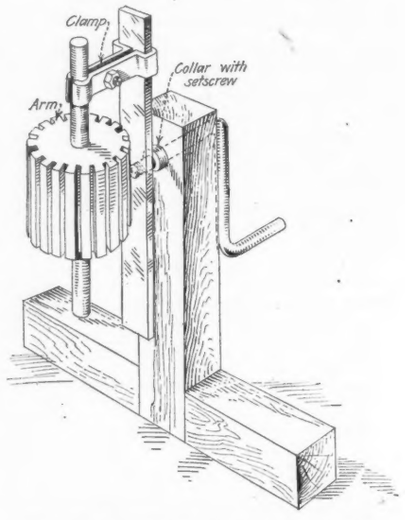
Electricians sometimes overlook overhead protection, as well as ventilation, for this type of mounting. Remember that near the ceiling the temperature is higher, and dirt from the floor above may give trouble.

Newark, N. J. EDWARD JAMES.

Simple Device for Winding Small Armatures—I should like to know if any of our readers can tell me how to construct a simple machine that can be made in the shop and used for rewinding small armatures of the fan and vacuum cleaner types. I should also like to know what other equipment is necessary for the rapid handling of this kind of work. Winding these armatures by hand is too tiresome and slow, and we do not have enough of this work to warrant the purchase of an expensive winding machine.

Brooklyn, N. Y. G. A. L.

G. A. L. can make a simple machine for winding small armatures by following the ideas set forth in the accompanying diagram. Take two maple blocks 2 in. by 2 in. by 12 in., notch out the center of one and the end of the other, and place them together to form a T. This is the support or standard for the device. About 1½ in. from the top of the vertical piece, insert a bronze bushing to take a ½-in. shaft.



An easily-made device that will save much time when winding small armatures.

The crank is made from ½-in. round iron, bent as shown in the diagram, and threaded on one end for a distance of ½ in. A piece of steel ¼ in by 1¼ in. by 12 in. is drilled and tapped at the center for the threaded end of the crank.

The clamps for holding the armature to this steel strip are made from strap iron, bent as shown in the accompanying diagram. E. H. WINKLER.

Chief Electrician,
Allen B. Wrisley Co.,
Chicago, Ill.

* * * *

In reply to the question asked by G. A. L., the diagram shows the construction of a simple armature winding machine that I made up and found to work very satisfactorily. This machine can be constructed in the shop at a very small cost and will effect a considerable saving in the time required to wind small armatures.

As may be seen, the armature is clamped by two holders *m m*. The screws on these two holders do double duty; first they tighten the clamp on the armature and, second, they hold the two brass pieces *d* which direct the

wire into the slots being wound. The wire is fed through the pulley *c* and thence down the guide *d* into the slot. The strip *f* is made adjustable so that the pulley can be moved for different sizes of armatures.

The shaft clamps *m* are fastened to strip *b*, as is shown in the diagram, so as to permit adjusting the device for different sizes of armatures.

The strip *b* is fastened to the shaft *t* which is revolved by means of a crank. The shaft *t* is threaded with about 220 threads between *p* and *q*. Resting on the threaded shaft is the lever *a*, the underside of which is threaded somewhat like a split nut, so that as the threaded shaft *t* is revolved the lever *a* is moved from left to right.

Having taken the commutator and fan off the shaft, (as only armatures in this shape can be wound on the machine) the armature is clamped in the holders *m m*. The lever *a* is put in such a position that the number of threads on the shaft to the right of it is equal to the number of turns it is desired to have in a coil. As the coil is wound the lever moves to the right and when it reaches the end of the shaft, indicates that the coil is completed. A loop is then made, the armature turned so as to bring new slots into position, the lever *a* is placed in the former position, and the next coil is wound.

It will be found advisable to have the crank connected to the shaft *t* by means of a few gears, rather than connected directly. This arrangement will speed up the work.

New York, N. Y. L. KONSTAN.

* * * *

What Kind of Wire Should Be Used Here?—We are having considerable trouble from grounds and shorts due to the insulation falling on the wires running from our pyrometers to the indicating and recording mechanisms. The pyrometer points are located in the stills and furnaces of a refinery, and the indicating instruments are 200 to 300 ft. away. Consequently, the wires are subjected to considerable heat at one end of the line while the other end is cool. The wires are carried in conduit and we have trouble with condensation in these pipes. Ordinary rubber-covered, double-braid wire rots out in less than six months. The so-called "flameproof" wire has not proven satisfactory in this application. Can any reader tell me what I can do to correct this trouble?

Tulsa, Okla. L. A. N.

If the pyrometer lead wires mentioned in L. A. N.'s question are of copper, I would suggest using No. 14 duplex lead-covered cable which is a two-conductor No. 14 copper wire; each wire is rubber-covered and braided and there is a serving of braid over both, which are then protected by a lead sheath. This wire will work under water and will stand a conduit temperature of about 375 deg. F.

If the conduits have a 4-in. space between them and furnace walls, hot oil lines, steam lines, etc., their temperature will usually be found to be below 300 deg. F.

Some pyrometers and thermocouples require special compensating lead wires (wires made of the same material as the thermocouples), so that the cold junction can be taken care of by a compensating coil in the indicator or the recorder. These wires can be purchased from the maker of the pyrometer, in lead-covered duplex form. This type of wire has never given us any trouble.

Chief Electrician CHAS. L. BROWNE.
Producers and Refiners Corporation,
Tulsa, Okla.

* * * *

L. A. N. will have no further trouble with his wires in conduit in very hot applications if he uses all asbestos insulation on his conductors. For the past few years I have used solid and stranded conductors with asbestos insulation, such as Deltabeston stove wire, with great success for pyrometer and other circuits around open-hearth furnaces and in other very hot places.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

In reply to the question asked by L. A. N., I would say that we have had similar trouble with wires in conduit on pyrometer work. The only remedy for this trouble that we have found so far is to do away with the conduit entirely and run flame-proof compensating leads in open construction from the thermocouples to the instruments.

The method of construction sometimes used has been to stretch small messenger wires well above the furnaces, the thermocouple leads being taken directly up to the messenger and carried along it in loops of flame-proof wire over to the instruments. This construction is reasonably good in appearance and gives very little trouble.

Electrical Dept., W. W. LANKTON.
Detroit Copper & Brass Rolling Mills,
Detroit, Mich.

* * * *

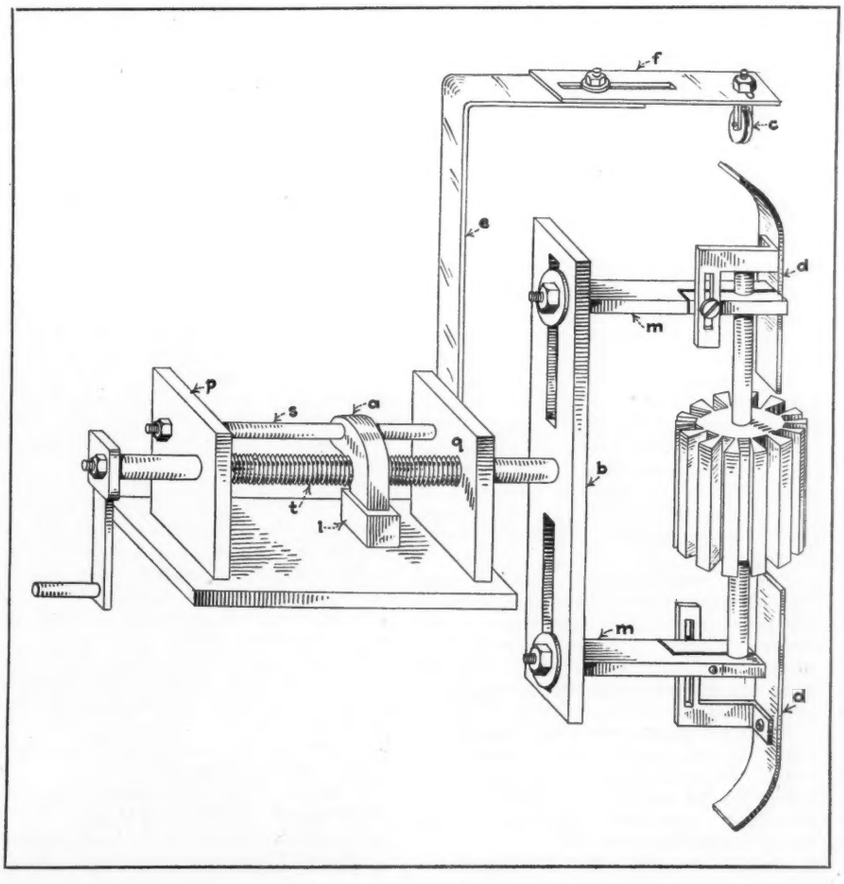
The trouble experienced by L. A. N. is due to air circulation in the conduit and can be eliminated by stopping the circulation of air through it.

When rubber-covered wire is run to the thermocouple, the heat of the still soon causes deterioration of the rubber insulation. When flame-proof wire is used, the insulation soon absorbs the condensed moisture, thereby causing a short.

The best method of overcoming this is to use a good grade of asbestos wire from the thermocouple to the point where the conduit starts to cool. This point is generally where the pipe runs through the wall of the room. From the cooling point to the pyrometer, use rubber-covered wire. At the junction box where the two types of wire are spliced, plug both ends of the conduit and fill the box with pitch or any insulating compound so as to prevent the warm air from entering the cool portion of the conduit.

Also, drill a small hole through the underside of the conduit at all low points to allow any condensation that may collect, to run off. Sometimes it is advisable to plug the conduit in two or more places where alternate sections are heated or cooled.

Here is a device that will speed up the winding of small armatures.



The above method is one that I have used with success in a chemical plant. I feel sure that it will answer L. A. N.'s purpose if the box is properly inspected once in a while, replacing any compound that may have run off.

Elizabeth, N. J. W. H. FREDRICKSON.

* * * *

Answering L. A. N., the trouble referred to is apparently due to condensation in the conduits, judging from the information given. The solution most readily applied would be to replace the rubber-insulated, braid-covered wire with rubber-insulated, lead-covered conductor. This change might require new conduit, although, if the conductor is not subject to, or in danger of, mechanical abrasion it might be run exposed.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

I think the first thing L. A. N. should do is to try and eliminate condensation in his conduit installation.

My experience has been with Brown Instrument Co.'s equipment, using type MA 30-in. base metal thermocouples on recording and indicating pyrometers. These are used for temperature measurements in our malleable iron annealing ovens.

We formerly used No. 12 rubber-covered extension leads but had trouble with grounds and shorts due to the roasting of the insulation. Asbestos-covered wire was tried with a little better results but after being installed for a while the insulation baked brittle and would not stand any alterations. Finally, we installed Type A extension leads made exclusively by the Brown Instrument Co., Philadelphia, Pa., to be used with their type MA thermocouples. These leads are composed of a stranded copper and a nickel-aluminum conductor very well insulated and woven together in duplex form. This company also manufactures several other grades of extension wire to be used with their several grades of thermocouples.

Since this installation was put in we have had very satisfactory results from our pyrometers. W. A. BERGSMA.
Chicago Malleable Castings Co.,
Chicago, Ill.

* * * *

Referring to L. A. N.'s question, I presume that a metallic circuit system is used in your pyrometer wiring; that is, there is no common return. This being the case I would recommend using duplex, lead-covered, No. 10 wire in about ¾-in. conduit. At the beginning and at the end of the conduit I would pour some pothead compound in the condulets. This will seal the end of the lead so that no moisture can get to the wire in the conduit. Peel off the lead inside the condulet for about ¾ in. below the end of the pipe. This can be done before the condulet is screwed on. The condulet should also be drilled and tapped for a ⅜-in. pipe plug at what will be its highest point when installed. Waste or oakum should be packed tightly around the lead an inch or so in the conduit. The condulet cover should then be put on and waste packed around the wires so that the hot compound will not flow out and be lost.

Melt the compound and pour it in at the drilled hole; fill to overflowing, as the compound shrinks when it cools. While it is still hot, screw the plug in the hole. If the heat is great enough to keep the compound molten or drippy, a fiber cover can be substituted for the porcelain and the holes for the wire drilled to a tight fit. It matters not whether the compound is molten or cool so long as it covers the end of the cable. The General Electric Company makes a compound which has a very high melting point and I believe that it would suit your case. Of course, the conduit should drain to one point, in this instance, and some means of eliminating the moisture should be provided.

The covering of lead is not very thick and it must be carefully handled if it is to give good results. In pulling in lead cable I usually feed the cable and have a can of cup grease handy, which I use so that the lead will not be scraped, and to lessen the power required for pulling.

GRADY H. EMERSON.
Asst. Chief Electrician.
Alabama Fuel & Iron Co.,
Acmar, Ala.

* * * *

I have had trouble similar to that experienced by L. A. N. due to steam getting in conduit lines. If L. A. N. will use asbestos-covered wire, give his conduit line a slight incline and have all fittings vapor-tight, he will have no further trouble. A small drain hole should be put at the lowest point in the conduit run so as to drain off condensed moisture.

Chief Electrician, E. N. DILLARD.
Booth Kelly Co.,
Springfield, Ore.

* * * *

In answer to L. A. N., it is evident that one cannot use a weather-proof wire and subject it to extreme heat, or use slow-burning wire in damp places. I doubt whether you can get any wire to suit both purposes at the same time.

I would suggest, first, that you arrange the conduit line so that it will drain off the condensation; try installing several outlet boxes with blank covers at regular intervals along the line. I would say about five boxes in every 300 ft. It may be necessary to drill a few extra holes in the boxes, ⅛-in. holes would be plenty large enough.

Pull in weatherproof wire, or even lead-covered cable, if necessary, up to the point where the heat becomes excessive. Then pull in slow-burning wire from furnaces to nearest junction box, and make splices to the weather-proof wire.

Another point; do not crowd the wires in the pipe. Leave plenty of room. There should not be more than three No. 14 wires in a ½-in. conduit otherwise crowding will take place, which should be avoided.

Los Angeles, Calif. H. A. NIELSEN.

Method of Drilling Holes Through Plate Glass—I have to drill some holes in plate glass ¼ in. thick and wish some of our readers would tell me the best way of doing this. I have tried various methods but without much success and shall appreciate your suggestions.
Little Rock, Ark. M. J. J.

In replying to M. J. J., he might use a method which proved satisfactory in making some chemical laboratory equipment which was constructed entirely of glass and required the drilling of several holes.

These holes were drilled by means of a triangular file turned in a brace. Files of the required sizes were ground smooth on all three sides, care being taken not to draw the temper of the steel. The drilling was rather slow and a stream of water was kept flowing across the holes to keep the drill cool and to carry away the glass dust. If it is not possible to use a stream of water, the drill should be moistened with turpentine. D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

In answer to M. J. J., I have tried many methods of drilling glass and the one I have found to be the most satisfactory for speed, accuracy and neatness is to use a piece of brass tubing, the outside diameter of which is the same size as the hole to be drilled. If the tubing is used in a hand drill with emery and oil as an abrasive, a hole can be drilled without danger of cracking the glass and only a slight pressure will be required.

A block of wood with a hole bored through it the size of the tubing should be used to center the drill properly. This block will keep the tubing in place until it starts to cut. A liberal amount of emery and oil should be used during the operation.

By using a dull hacksaw blade with emery and oil for the abrasive, glass can be easily and neatly cut when an ordinary cutter can for any reason not be used. JOHN GRIVA.
Electrician,
Hotel Statler,
Detroit, Mich.

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In answer to the question by M. J. J., he can easily drill holes through ¼-in. glass by putting a few drops of turpentine on the glass where the hole is to be bored and using a drill made from an ordinary 8-in., three-cornered file.

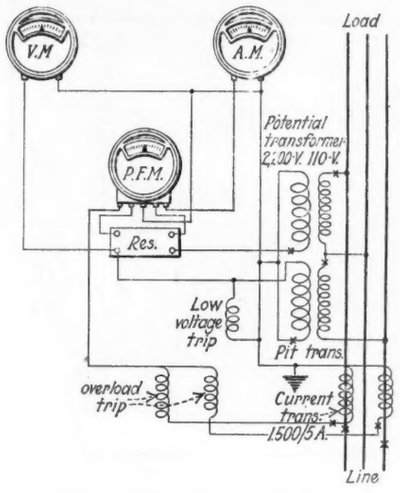
The tempered end of such a file should be ground on an emery wheel to a very sharp, three-sided point and the handle end supported in a drill bit stock.

You can get smoother holes by first drilling a small hole, using a small file, and then boring it to the desired size with the large drill.

In connection with glass working I might say that almost any thickness of glass can easily be cut with an ordinary pair of tin snips, if you hold both the glass and the tin snips under water while doing the cutting. The size of the snips will depend upon the thickness of the glass that is to be cut.

Chief Electrician, A. C. BARKER.
W. S. Libbey Co.,
Lewiston, Maine.

Why Do These Meters Not Register?—We have a Weston power factor meter, Model 356, serial No. 790, and a Weston ammeter, Model 156, serial No. 43008, mounted on a switchboard manufactured by the Condit Manufacturing Co. and connected as shown in the diagram. The connections from the switchboard to the current and potential transformers were made by my



workmen. The polarity marks on the transformers are as indicated. The ammeter reads zero when power is flowing through the switchboard. The power factor meter likewise remains in the same position as when power is off the board. Is the connection scheme shown in the accompanying drawing correct? If so, what do you think is wrong and what tests should I make to locate the trouble?
Sharon, Pa. C. F. C.

Answering C. F. C., it is not possible to determine or suggest the cause of non-registration of the meters shown in the diagram. Assuming that the internal condition of each meter is satisfactory the connections seem to be conventionally correct. No details are given as to the wiring runs between the transformers and the instruments. Assuming that the voltmeter reads correctly and that the potential transformers are operating, the current transformers should be tested as follows: Short-circuit each transformer, at the secondary terminals, through an ammeter. Should readings be obtained which check approximately with the load that is being carried, it is a definite indication that there is trouble in the circuit in the portion which includes overload trips and power factor meter.

In the absence of any description of the wiring, no guess can be made as to the trouble which may exist, except that it might be either a short-circuit, if the conductors are carried in the same conduit, or a ground in the lead between the overload trip coils and the power factor meter. An ammeter connected between the common lead referred to and ground, or to the common lead from the current transformers will show whether this portion of the circuit is in operating condition. If the ammeter gives a reading of the same value as obtained in the earlier test by shorting a transformer, then the connection through the power factor meter is causing trouble.

It is barely possible that there may be an open circuit in the connections, but in the case of a current transformer this condition could not exist even under light load, as it would be shown by the heating or possibly a breakdown of the current transformers.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

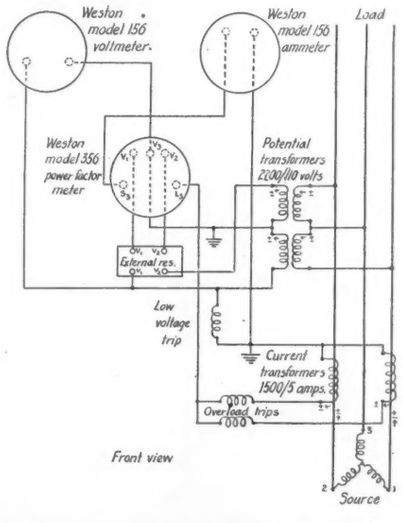
* * * *

As the back connection studs are not shown in their actual location in the diagram of connections for a Weston ammeter and power factor meter accompanying the question by C. F. C., it is assumed that the proper terminals on the back of the power factor meter have been used, and that either Weston transformers are used or the polarity marks have the same meaning as those on Weston transformers.

If these assumptions are correct, then the only error in connections is that the current connections to the power factor meter are reversed.

However, with the connections shown the ammeter should indicate correctly and the power factor meter pointer should deflect below or above the ends of the scale. Since they do not indicate at all it is evident that there is an open circuit in the current connections, possibly through using the wrong terminals on the power factor meter. A simple test for this is to short-circuit the current circuit connections to the power factor meter and if the rest of the circuit is correctly connected, the ammeter should show the proper indication.

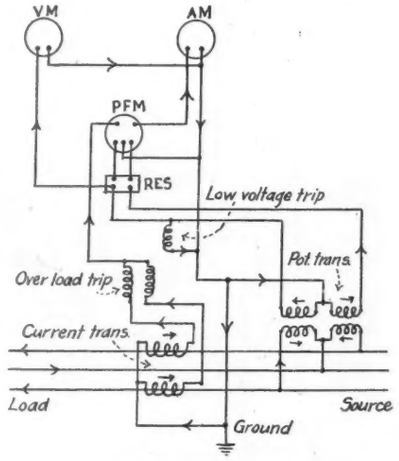
The accompanying sketch shows the proper connections for the instruments and accessory apparatus. It is assumed that two current transformers are used for connection to other instruments, such as wattmeters, as only one in the "middle line" is necessary for a power factor meter. W. N. GOODWIN, JR.
Electrical Engineering Dept.,
Weston Electrical Instrument Corp.,
Newark, N. J.



This shows the proper connections for a Weston power factor meter, using two current transformers.

* * * *

If C. F. C. will trace his current in the common return wire, he will find that he has the current traveling in at his current transformers and in the opposite direction, that is out, from his potential transformers. This will not work, as the meters will act as though connected as a shunt on one wire; that is, the current is trying to go out at both terminals at the voltmeter and



Connections for power factor meter, ammeter, voltmeter and relays.

trying to go in at both terminals at the ammeter. In fact, the current is not flowing at all. If he will connect them as shown in the accompanying diagram his meters will all register. Should the power factor meter read lead instead of lag, he can interchange two potential transformer lead wires, and if the pointer goes off the scale in the lead direction he should change both the potential lead wires and also the current wires.

He should always connect his potential transformer behind his current transformer, as shown in the diagram. when connecting switchboard instruments so that the ammeter and wattmeter will not register the current used by the potential transformer, as this load should never be registered on the meters. WILLIAM P. AMANNS.
Chief Electrician,
Knoxville Iron Co.,
Knoxville, Tenn.

* * * *

In answer to C. F. C. as to why his meters will not register, I would suggest that he reconnect his current transformers using one current transformer for the ammeter and one overload coil and the other current transformer for the current element of the power factor meter and the other overload coil.
Longview, Wash. B. W. HAMILTON.

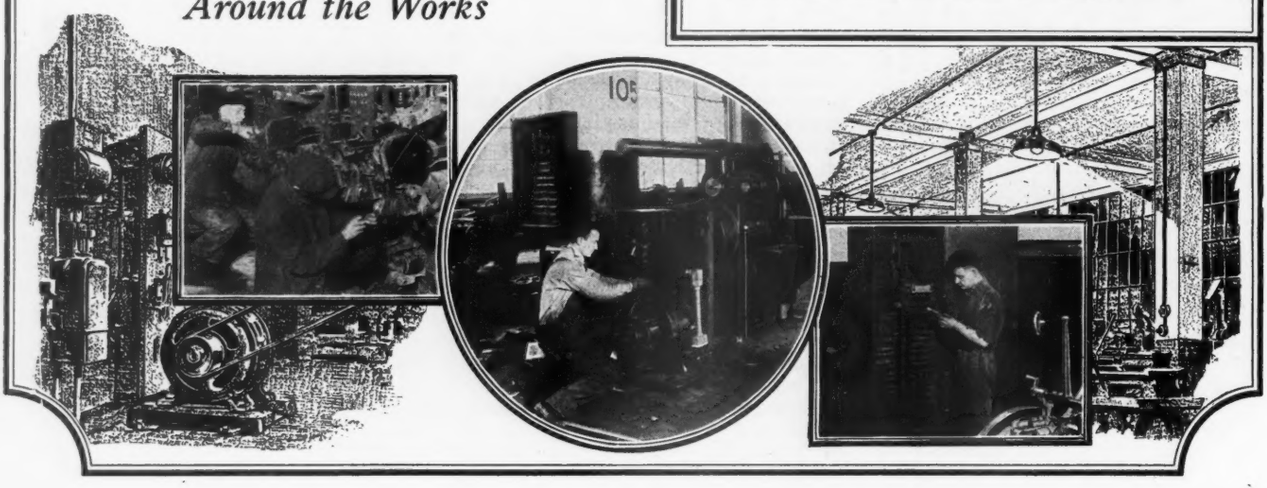
* * * *

The diagram which accompanies the question asked by C. F. C., is apparently correct. The connections to the power factor meter may be checked by taking a piece of wire and short-circuiting the current terminals of the instrument. The pointer should move toward lag. If it moves toward lead the potential connections should be reversed on the line side of the power factor meter resistor. I suggest that C. F. C. test the circuit from the current transformers for an open circuit.
Chief Electrician, R. M. BUSH.
Tubige Artificial Silk Co.,
Hopewell, Va.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Factors Involved in Layout of Lighting System for Pattern Storage Building

ASIDE from the illumination requirements, the design of lighting systems for pattern storage buildings should receive special consideration from the engineer, due to the great fire hazard that is involved. Pattern storage buildings are built without windows, to reduce the fire risk. Therefore, natural light need receive no consideration in the illumination design. In this application, as in every other, electric lighting has replaced oil and gas for illumination where full consideration has been given to the lighting problem. It is more convenient, less expensive, and very much safer than any other form of illumination.

In the modern, re-enforced concrete, pattern storage building none of the floors or rooms is connected with any other; there are no halls, stair wells, nor elevator shafts within the building. Stairs and elevators are on the outside of the building, and all doors are of fireproof construction, each with a second door inside the wall arranged to close by gravity upon the melting of a fuse link.

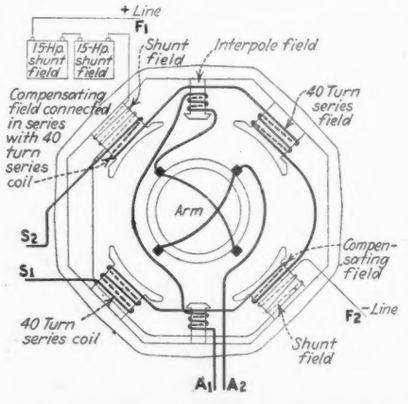
In the lighting system for this type of building there should be no switches inside the outer walls. Cast-iron enclosed, quick-break safety switches should be mounted outside on the wall near the doors. All wiring should, of course, be protected by rigid steel conduit. All lamps should be protected from breakage by very strong, specially-constructed steel guards to prevent the destruction of the lamps and perhaps damage to the sockets. A large pattern striking against an unprotected lamp might result in a flash due to the conducting parts of the socket coming in contact and so set fire to the pattern and perhaps the building.

Special lighting designs are recommended for pattern storage buildings as a form of insurance which, at a low cost, will prevent fire losses which might otherwise result from poor construction and installation.

Electrical Engineer, D. W. BLAKESLEE.
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

Emergency Method of Operating Shunt Motor Having Grounded Field Coil

AN APPROACH table to a shear handling strip from the hot bed of a hot strip mill was operated by a 20-hp., 230-volt, direct-current, shunt motor, controlled by a reversing drum controller having five points. In spotting the steel to obtain the proper length for shearing, much plugging is necessary. Endless trouble was experienced with this drive as it was subjected to plugging voltage which may run up to almost twice normal voltage and which caused field and armature failures to ground.



The two defective shunt-field coils were replaced with series coils wound with 40 turns of wire.

These were connected in series with the compensating windings so as to give additional series characteristic to the motor fields. The two remaining shunt-field coils were placed on opposite poles and connected in series with two 15-h.p. shunt-field coils placed outside of the motor and which were intended to limit the shunt-field current to somewhere near normal.

Due to the fact that this motor was to be replaced by a compound-wound, mill-type motor, with automatic control, no spares were available or on order. Under such circumstances it was only natural that this equipment should fail and leave us in a bad way at an inopportune time. Two shunt-field coils grounded, burning the wire in such a manner that repair without complete rewinding of the coils was impossible. In order to keep the mill in operation it was necessary that this shear table be made to run, hence it devolved upon us to find a method of repairing this motor in very short order.

The two defective shunt-field coils were removed and the remaining two good field coils were placed on opposite poles in the motor as it was believed that better flux distribution would be obtained in this manner. In series with the two good field coils were connected two shunt-field coils from a 15-hp. motor of similar make, as is shown in the accompanying diagram. The two 15-hp. shunt coils were used outside of the motor as shown, and were intended merely to act as resistance to limit the field current to somewhere near normal. Resistors could have been used, if available.

A permanent resistance was then placed in series with the armature to hold the speed down to normal, for the motor ran fast due to the full action of only two field poles and the induced field of the other two poles. Because the friction load was small (16 amp.) in comparison to the rating of the motor (80 amp.), the reduced voltage at the brushes (166 volts) due to the permanent resistor caused no trouble. Although the brushes sparked considerably, it was not enough to prevent temporary operation of the machine

while proceeding with the winding of series coils for the field.

Not having any wire of suitable size to rewind the shunt-field coils, and believing that more series characteristic would be helpful, it was decided to make two series coils to use in place of the defective shunt coils. These were made up by winding 40 turns of two No. 8 d.c.c. wires in parallel. Each layer of wires was, of course, insulated.

These two series coils were then placed on the two field poles from which the defective shunt-field coils had been removed and connected as shown in the accompanying diagram. After the installation of these series field coils, the sparking at the brushes practically stopped. Also the motor speed was slowed down enough so that the series resistance in the armature lead was no longer needed and hence discarded.

The motor operated satisfactorily in this manner for nearly two months without failure; in fact, it operated until replaced by the new mill-type, compound-wound motor.

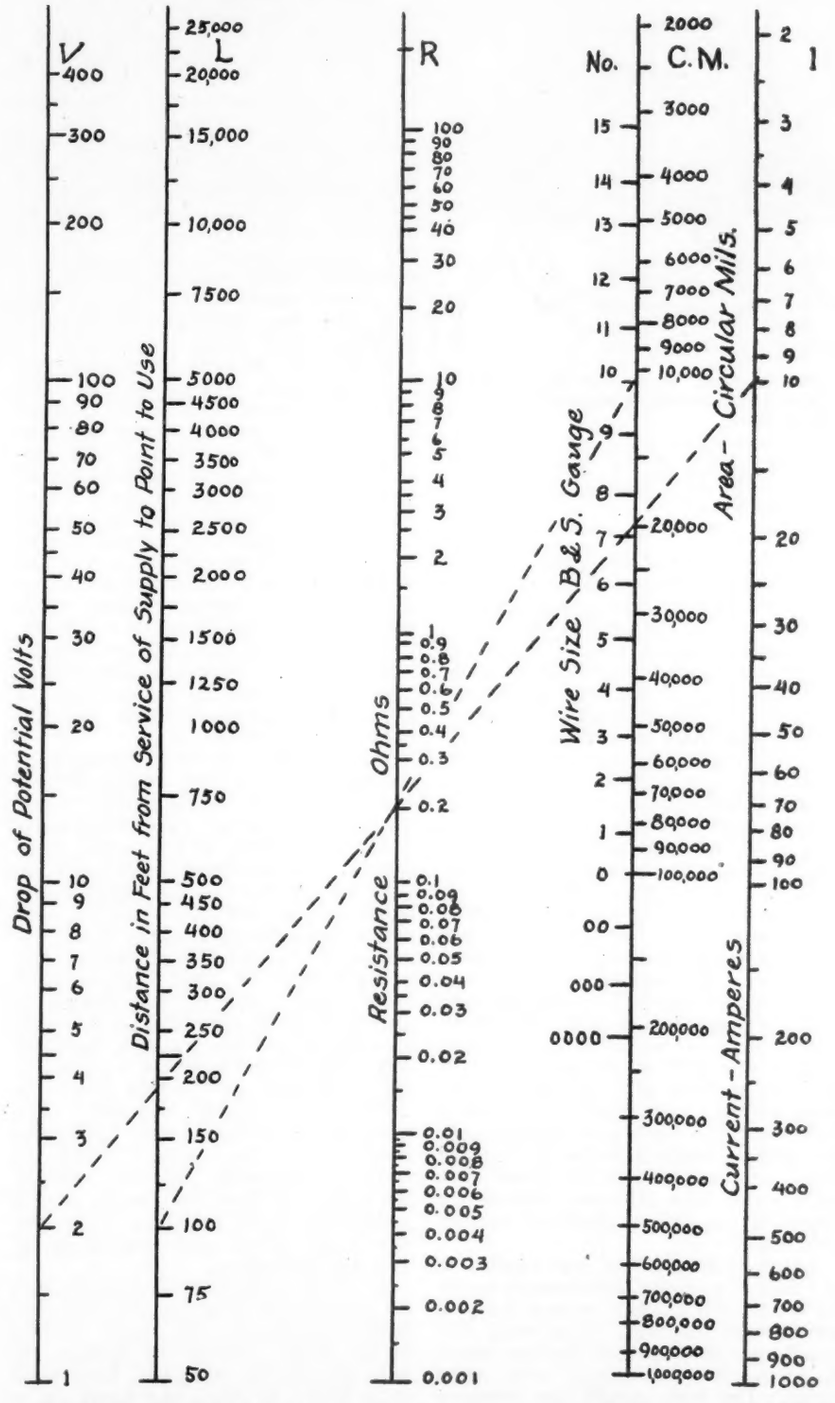
Chief Electrician, Laclede Steel Co., Alton, Ill. L. P. STAUBITZ.

Chart for Calculating Proper Size of Copper Wire

IN CALCULATING the proper size of wire to be used for a given installation, consideration must be given to the distance from the source of supply to the point of distribution, the number of amperes to be carried, and the permissible voltage drop between the source of supply and the point of distribution. The formula that is commonly used for determining wire size is as follows: Circular mils = [feet (supply to distribution) $\times 2 \times 10.7 \times$ amperes] $\div$ volts lost. Quite often it is inconvenient to go to the trouble of multiplying and dividing all the factors given in the above formula; so the chart shown in the accompanying diagram was prepared for the purpose of eliminating the labor of these computations.

In this diagram it will be noticed that there are five scales. The first one at the left which is marked *V* represents volts and is the permissible drop of potential between the source of supply and the point of distribution. The second scale at the left is marked *L* and represents the distance in feet from the source of supply to the point of distribution. The middle or third scale is marked *R* and is calibrated in ohms. The fourth scale is marked *C.M.* and is calibrated in wire sizes and circular mils area of the conductor cable. It represents the proper wire size that is the result of the computation. The fifth scale or the one at the extreme right is marked *I* and is calibrated in amperes.

Assume that we have a direct-current motor that takes a full-load current of 10 amp. and that this motor is situated at a distance of 100 ft. from the source of supply. Also, assume that we desire that the voltage drop from the source of supply to the motor shall not exceed 2 volts. Place a straight edge on 2 volts on the drop of potential or *V* scale at the extreme left and also have it line up with 10 amp. on the current or *I* scale at the extreme right. On the middle scale, *R*, we read 0.2 ohms. In other words, if we have a drop of potential of 2 volts and a current of 10 amp., the resistance of the circuit will be 0.2 ohm. Now place the straight edge on 0.2 ohm on the *R* scale and upon 100 ft. on the *L* scale, the second scale from the left, and on the wire size or *C.M.* scale



To find size of wire to carry 10 amperes a distance of 100 ft. with a 2 volt drop of potential, place a straight edge on 2 volts on V scale and 10 amperes on I scale and read 0.2 ohms or R scale, as shown by dotted line. Now place straight edge on 0.2 or R scale and 100 ft. on L scale and read No. 10 as size of wire on C.M. scale.

By means of this chart the proper wire size for a given installation may be quickly determined as shown by the example at the bottom of the chart.

read the size of wire, which is No. 10. Consequently, we find that a No. 10 wire is required to transmit 10 amp. a distance of 100 ft. with a drop of potential of 2 volts.

The current that is to be carried by the wires can usually be determined from the nameplate of the machine to which the wires are to be connected. In the case of direct-current machines, the current will be given in amperes and in the case of alternating-current machines, particularly two-phase and three-phase machines, the current will be given in amperes per terminal These values of current are the ones that should be used in calculating the size of wire.

In case the current is not given but the horsepower or kilowatts and voltage are given, the current can readily be calculated from the following formulas:

For direct current, $I=W\div V$.

For single-phase alternating current, $I=W\div(V\times P.F.)$

For two-phase alternating current, $I=W\div(2\times V\times P.F.)$

For three-phase alternating current, $I=W\div(\sqrt{3}\times V\times P.F.)$

In each of the above formulas I stands for current in amperes, W = watts, V = volts and $P.F.$ = power factor expressed as a decimal rather than in per cent. Horsepower can be converted to watts by multiplying by 746 before using in the formulas.

To find the best size of wire to use for balanced three-phase, three-wire circuits, the current per terminal or current in each wire is determined as described in the foregoing. The wire size is then calculated by means of the chart in the same manner as given in the previous examples. The circular mill area of the wire size thus found must then be divided by 1.154 or multiplied by 0.866 to obtain the correct size of wire for use on a balanced three-phase three-wire circuit.

In using the accompanying chart it should be remembered that distance is taken as the number of feet from the source of supply to the point of distribution or point at which the wires are to be run, rather than the total length of the wire that is used.

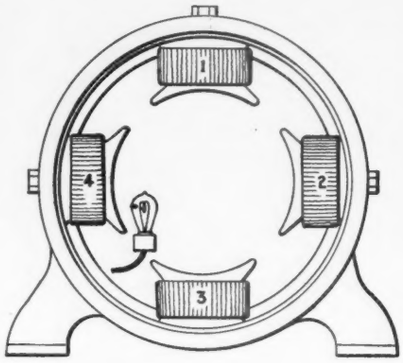
CHARLES F. CAMERON.

Rock Springs, Wyoming.

Locating Reversed Field Coil With Carbon Lamp

SOME time ago while running a test on a synchronous motor, which had just been installed, it was noticed that the direct-current machine which was to be used to furnish current for excitation and to bring the synchronous motor up to speed, would not accelerate and that it sparked badly at the brushes. Shifting the brushes did not remedy the trouble. The wiring connections were checked and found to be correct; also the connections inside the motor exciter were checked and found to be all right. It was then decided to test the field coils for polarity; so the armature was removed. The question then arose as to how the polarity of the field coils could be checked, as a compass was not available.

This difficulty was overcome by using a carbon lamp in the following manner. One side of the globe of a 16-cp., carbon lamp was marked with black shellac as shown in the sketch and connected to an extension from the direct-current, plant lighting system. The shunt-field coils of the exciter were now energized from the switchboard and the carbon lamp placed near the pole face of each coil in succession with



The filament of a lighted carbon lamp is attracted or repelled by the field pole.

By holding the lamp in the same relative position over the face of each pole, the polarity of each pole relative to the remaining poles, can be determined.

the marked side of the globe towards the pole face. By watching the lamp filament closely it was noticed that at the first coil the filament of the lighted lamp was deflected toward the pole; at the second pole it was deflected away from the pole; at the third and fourth poles it was also deflected away, which showed that there were three field coils in succession having the same polarity. In other words poles 2, 3, and 4 were either all north poles or all south poles. The connections of the coil on No. 3 pole were reversed and the machine reassembled, after which it ran in an altogether satisfactory manner.

The reason the lighted lamp acted in this manner was because the carbon filament carrying direct current acted as a small electromagnet which was attracted or repelled when brought close to a shunt field pole. The black spot was placed on the lamp to insure that it was held in the same relative position in front of each pole. If the lamp filament were repelled by a north pole when the black spot was towards the pole it would likewise be repelled from a south pole if the black spot were away from the pole. Hence the necessity for putting the black spot on the lamp.

Later, this same test was applied to the field of an 85-kw. synchronous motor by connecting a 32-cp. carbon lamp in series with the field. Even with this small amount of current flowing—about 1 amp.—the indications were quite clear. The best results are obtained by holding the lighted lamp over the face of the pole and momentarily turning off the current to the lamp. Then each time the current is turned on the filament will move sidewise, thereby indicating the relative polarity.

New Westminster, B. C. W. L. STEVENS.
Canada.

Method of Making a Sleeve Splice on Heavy Cables

UNDER the above heading there was described by S. H. Samuels on page 153 of the March issue of INDUSTRIAL ENGINEER, a method of splicing a 500,000 circ. mil. cable which, although a sleeve was used, differed considerably from the ordinary sleeve splice.

The method described was to cut the heart out of one section of the cable for a distance of a few inches, leaving only the outer strands. The other section of cable was treated in just the opposite manner—the outer strands being removed and the inner ones left. The result, when the inner strands of one piece had been pushed inside of the outer strands of the other and the two sections butted closely together, was a dowel joint, which was reinforced by a split sleeve around the outside. The joint was then soldered and insulated.

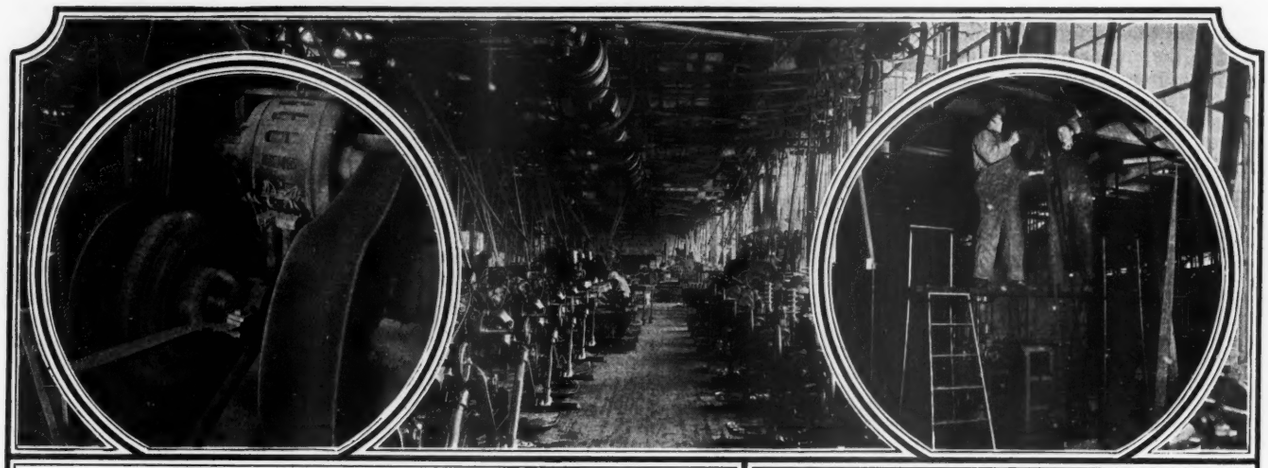
While such a joint is an improvement, for large cables, over the ordinary sleeve joint (where the ends of the wire are merely butted together inside of a split sleeve and then soldered) and should be perfectly satisfactory in places where there is no strain on the cable, which the writer of the article said was the case in this instance, yet it is not the safest one to use with heavy cables that are under a strain. I have known of cases where very similar splices have pulled apart.

Under a strain, the ordinary mechanical joint of the Dossert or some similar type, should show up better; best of all, in my opinion, would be the ordinary wrapped joint.

This is made by first cutting back the insulation, on each of the sections to be spliced, for several inches. Then, for about half of this distance the heart is cut out of both of the cables to be spliced. The outside layer or layers of wire are fanned out at right angles to the axis of the cables and the ends of the two cables are butted closely together, the strands being interlaced and brought down to their original positions. Next, one of the strands is wrapped tightly around all of the other strands, which are bunched together. After this strand has been wrapped as far as it will go, another strand is taken and similarly wrapped. This procedure is followed until all of the strands have been used. When the work is completed you will have, if the splice had been well made, a joint which even before soldering will be mechanically strong and electrically of very low resistance.

However, soldering will increase both its mechanical strength and its electrical conductivity, and should be done in all cases. Instead of heating the wire directly by means of a blow torch it is better to bring the wires up to the required temperature by pouring the molten solder over the joint, from one ladle to another, after the use of the proper flux. By pouring the solder over the joint the wires will be kept cleaner than if the flame impinges directly upon them.

Westfield, N. J. G. H. MCKELWAY.



Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Standardized Type of Platform for Mounting Motors on Columns

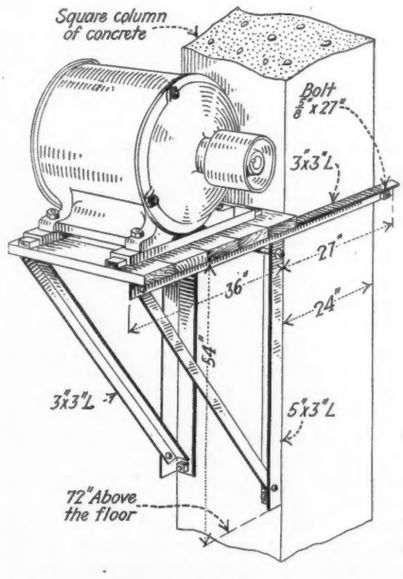
RECENTLY a large fireproof warehouse was taken over by an industrial firm for manufacturing operations and group motor drives were installed at various points. The building had a 30-ft. bay along each side and a 12-ft. aisle through the middle. It was desired to put the motors in this aisle where they would be more out of the way, would not shut off any light, and where they could be fed from a common power line down the center of the room. However, it was desired they be accessible, substantially supported, not interfere with trucking operations, and that their installation cost be low.

The man at the head of the millwright and maintenance departments decided upon the motor stand shown in the accompanying illustration. As more than a score of them would be required, he decided to reduce the manufacturing cost by making only one type and size of stand, regardless of whether a 5- or 20-hp. motor was to go on it. It was decided to attach the motor stands well up toward the ceiling on the 24-in. by 24-in. reinforced concrete columns alongside the aisle.

These stands were made of angle iron, which is the simplest and strongest form in which metal with the desired working faces could be secured, and were designed so that no bending or special cutting was needed for fabricating. They were made up in triangular shape and riveted at the intersections. The top legs were made long enough so that a bolt could be put through the two columns, as shown in the drawing. The motors were placed on the side of the column toward the aisle; thus all of the belt pull is toward the column and the supporting frame is partially relieved of this strain.

The frames were drilled for four expansion bolts to attach them to the face of the column on the aisle side. Two of these ¾-in. expansion bolts set in lead poured in holes 4 in. deep in the column face are shown in the drawing. The use of expansion bolts necessitated a minimum of cutting on the columns. To locate these holes for drilling, the frame was placed against the column, the tops leveled up throughout, and the holes scribed and drilled.

A wooden platform of planks dressed from 2-in. stock, was laid on top of the horizontal angles and bolted to them. The motor or the motor base was then bolted to this platform. All sharp corners were rounded off and the installation given a coat of cream-tinted paint. The rows of uniform platforms, all mounted at the same height and supported by a framework below that was not designed in hit-or-miss fashion, added to rather than detracted from the appearance of the room.



This standard design of motor mounting was used for the installation of a number of motors in one shop.

Method of Repairing Roller Bearings in Loose Pulleys

EVERYONE who has seen the inside of a silk throwing mill will remember the long rows of machines, each with scores of spindles and as many spools of silk cord being rapidly unwound. Though apparently the lightest of work, a room 100 ft. long full of these machines, and with 20-ft. machines set in a double row, may require 100 hp. The belt drive to these machines is received by what is known as the "head," which is really a tight-and-loose-pulley arrangement for two belts with one loose pulley. Many of these machines have 1⅛-in. shafts and the loose pulley has a 3-in. hub length. All modern machines have a roller bearing on this pulley, which greatly reduces the maintenance cost over that of the older, plain bearings.

One mill that was newly built and newly equipped began to think it was free from the loose-pulley curse as, year after year, these roller-bearing pulleys ran smoothly. Then, as if by common consent, trouble appeared on several machines at the same time. Investigation showed that the cages of the bearings had long since come apart and that the rollers had been running around freely until they packed and jammed, along with miscellaneous bits of metal, and refused to go any further.

No spare bearings were on hand. What little thought had been given to this contingency was that the bearings would wear out gradually and would show this letting down in plenty of time to order spare parts. The sleeves were good and the shafts also, but the rollers were completely "shot."

At first it was planned to put in plain bushings, and everyone mentally groaned at the thought, but the master mechanic requested to be allowed to try a home-made roller bearing expedient and his request was granted. At the present time, nearly all the machines in the mill have suffered from

this bearing trouble and all have been fitted with these same home-made bearings; so their wearing qualities must be worth telling about.

It was found that $\frac{7}{16}$-in. round steel would just fill the space between the sleeves and the slightly worn shaft and so pieces of cold-drawn steel were cut off $\frac{1}{8}$ in. shorter than the hub length. Eleven of these were put in; the twelfth one missed going in by about $\frac{1}{16}$ in., but the 11 worked nicely and they were allowed to space themselves as they would. The pulley so bushed was a good fit on the shaft. The end collars took good care of any side movement, either of the pulley or the rollers.

Two years have elapsed since the first of these bearings were "replaced." The first rollers used are now being thrown out as worn too small and in their place are inserted rollers of $\frac{7}{16}$-in. cold-drawn tool steel, unannealed. Case-hardened rollers were tried on a few machines but they were less satisfactory than the plain cold-drawn steel, as they were warped from the heat treatment and, as a consequence, they wore out of round and wore the shafts considerably.

The rollers are sawed off with a hack-saw. Then the sharp corners are filed off in the lathe and the pieces are ready to use. The replacement cost is low and these rollers can be made up at a moment's notice.

DONALD A. HAMPSON.
Plant Superintendent.
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

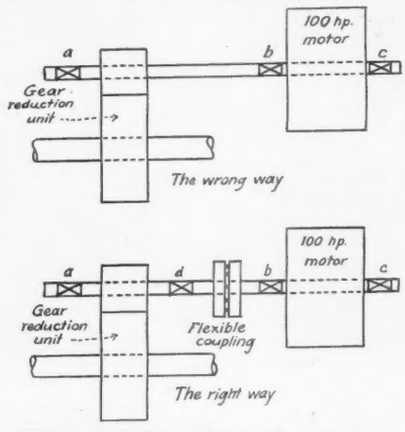
Installation of Flexible Coupling and Extra Bearing Saves $195 Yearly

FREQUENTLY plant operating men overlook the apparently small matter of placing a coupling between a source of mechanical power and a driven machine. In many cases the question is not brought up until considerable damage has been done to an expensive piece of equipment.

In 1915 our company tried some Francke flexible couplings (Smith & Serrell, Newark, N. J.) on rubber mill drives in our plant at Akron, Ohio. The value of a flexible coupling on some of the drives was so apparent that it led to additional purchases, and in 1917 we began using them at our College Point, Long Island, plant. Recently when we adopted individual drives for the Butler, N. J., plant we installed Francke flexible couplings throughout.

We manufacture hundreds of hard rubber products including a large number of radio supplies, combs, and so on. The flexible couplings are employed in driving all kinds of rubber machinery, including washers, mixers, grinders, calenders, and so on. We also employ flexible couplings on our tin mill drives.

These mills are driven by induction and synchronous alternating-current motors operating generally at about 600 r.p.m. Also, a number of variable-speed, direct-current motors, giving speeds of 300 to 900 r.p.m., are used on the finishing work or tin mill drives. Gear reduction units, most of which are of the herringbone type, with a reduction ratio of about 6 to 1, are employed on practically all drives. The flexible couplings are used between the motors and gear reduction units.



These sketches show the proper way to install a drive, with a flexible coupling between the drive and the reduction unit.

All the drives are equipped with a braking device on the motor so as to protect the operator and machine. On the d. c. motors and the a. c. synchronous machines, electro-dynamic braking is employed, while the a. c. induction motors are equipped with hand-reset, electrically-actuated, mechanical band brakes. The braking systems are adjusted to stop the machines very quickly, and so throw a severe stress on the couplings whenever the brakes are set. Starting the machines also throws considerable strain on the couplings. In spite of this severe service these couplings have stood up very well. Since they have a certain amount of spring, they relieve the shaft and the equipment of a considerable jar when the machinery is started or stopped suddenly.

A flexible coupling has many advantages over the use of a solid shaft or a rigid coupling, with which there is danger of bearing trouble, caused by misalignment after wear has set in. Such misalignment causes whipping of the shaft, with consequent additional wear. Furthermore, when herringbone gear reduction units are employed it is advisable for the shaft to have some end play, so that the gears will mesh properly; otherwise there will be considerable wear on the gear teeth. These flexible couplings permit the required amount of end play and also permit giving the armature enough end play so that it can move to its correct magnetic center. If no allowance is made for such movement a. c. motors will draw additional magnetizing current, which lowers the power factor and decreases the efficiency.

We use extreme care in lining up our machinery and, therefore, the greatest advantage we derive from the flexible coupling is the end play which it affords. However, there are times when, due to bearing wear, a shaft gets out of alignment without being noticed.

The couplings require very little attention. We inspect them every three months merely as a safety precaution to detect signs of wear on the pins, and as soon as there are any indications of more than ordinary wear we replace the pins. On some drives the pins have not been replaced for ten years.

When it does become necessary to renew parts the job can be done very quickly because the parts are interchangeable. While the savings effected by a flexible coupling, compared with a rigid one or a solid shaft, are quite difficult to calculate in every case, it is conservative to state that many of the couplings have paid their cost many times over in the repairs they have saved. These couplings can be considered in the light of insurance on expensive machinery and equipment.

A specific case which shows how these flexible couplings prove a profitable investment is illustrated by the attached diagram which shows a 100-hp. drive on a metal finishing mill. The upper sketch shows the wrong method of connecting to the gear reduction unit, which is the way it was formerly done, while the lower sketch shows the better way, as it is done now.

With the arrangement shown in the upper illustration, bearing *a* had to be rebabbitted two or three times per year, because of the whipping of the shaft. By ading an extra bearing *d*, and a flexible coupling, as shown in the lower sketch, this repair cost was cut down to almost nothing. The added investment in the extra bearing and the flexible coupling, was about $250 and the total operating cost amounts to only $51.75 per year, as shown in the accompanying cost sheet.

Savings Effected by Using a Flexible Coupling and an Extra Bearing

Fixed costs on flexible coupling and extra bearing	
Depreciation (cost + installation expenses) $250.00×10%.	$ 25.00
Average interest* on the investment at 6%=(11÷10)×($250.00×0.06)÷2	9.25
Estimated annual allowance for repairs and maintenance (5%)	12.50
Added lubrication cost on the one bearing	5.00
Total additional cost annually	$ 51.75
Cost of rebabbitting bearing three additional times per year—	
Labor dismantling machine each time	$30.00
Labor and material rebabbitting bearing	35.00
Total	$65.00
Total additional cost per year—3×$65.00	$195.00
Fixed costs on flexible coupling and extra bearing	51.75
Net annual saving	$143.25
Net annual return on the added investment	57%

* Allowing for interest earned by depreciation reserve.

On the basis of three additional babbittings for bearing *a* each year, there is a gross saving of $195. If we subtract from this saving the cost of operating the flexible coupling and the extra bearing, *d*, there remains a net annual saving of $143.25, which represents a net annual return of 57 per cent on the investment.

Mechanical Engineer, N. A. COZZENS.
American Hard Rubber Co.,
New York, N. Y.

In the Repair Shop

This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Selecting Material for Small Motor Bearings

SOME repairmen are under the impression that small motor bearings can be made satisfactorily from any kind of bearing materials. This is not the case, judging from my experience while in charge of a repair shop handling all kinds of small motors.

We repaired all kinds of appliances having high-speed motors, such as vacuum cleaners, drink mixers, and the like, and at one time considerable trouble was encountered on account of new bearings freezing shortly after they were installed. As our shop was equipped with lathes, rush bearing jobs were turned out by one of our workmen. Many cleaners and washing machine motors came back with frozen bearings shortly after being sent out equipped with bearings of our own make. Our first thought was that the customer had failed to keep them well oiled.

New bearings of the same material were made and sent out with the same results, although care had been taken to see that they were properly oiled. We were not having trouble with factory-made bearings, which gave very good service. Upon checking up on the materials used, I found that we were making bearings from cold-rolled brass obtained from a local hardware store at a low cost. A search through our stock room brought forth plenty of good bronze bearing material in sizes best suited for our bearings. From that time on all bearings were made from this material, and there were no come-backs or complaints. A test set ran very well for hours without oil before being damaged in the least.

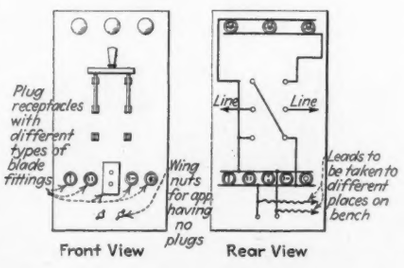
The heating of small bearings is much greater, in proportion, than in the case of large ones, due to the absence of flowing oil carried onto the shaft by rings. Therefore, a high grade of bearing material should be used on all small motor bearings, as it is the cheapest in the long run. The co-efficient of expansion of brass is higher than that of bronze, which sometimes permits bearings to freeze regardless of the amount of oil used.

Chicago, Ill. CARL G. HOWARD.

Layout of Panel for Testing Electrical Equipment

IT IS common practice in repair shops to put a lamp in series with the test leads used for detecting short-circuits and other defects in electrical equipment. The testing panel shown in the accompanying illustration has the advantage that lamps may be cut in series with the leads or full line voltage may be put on the equipment under test, by throwing over the double-throw switch. Furthermore, the lamps may, if desired, be mounted away from the panel, so that there will be much less danger of breakage, while the panel itself may be placed conveniently close.

As will be seen from the left-hand diagram, this testing panel consists of a double-pole, double-throw switch, two or three lamps and several plug receptacles with different types of blade fittings, all mounted on a suitable base. Wing nuts are provided at the bottom of the panel for connecting apparatus that is not fitted with a plug. If flush-type receptacles and a back-connected switch are used the panel will present a very neat appearance. The diagram at the right shows how the panel is wired.


Plug receptacles with different types of blade fittings
Wing nuts for app having no plugs
Front View
Line
Line
Leads to be taken to different places on bench
Rear View

When the switch is thrown up the lamps are cut into the testing circuit; when it is thrown down the lamps are cut out. The diagram at the right shows the connections on the back of the panel.

Electrician, Riordan Pulp Co., Temiskaming, Que., Can. J. H. SAUVE.

Making Quick Repair of Broken Motor Frame

WE HAD an accident in which one of the end frames of a 1-hp. motor was broken at a time when it was very badly needed. It was a single-phase, 60-cycle, repulsion-induction motor, running at 3,600 r.p.m from the lighting current supply. In a few minutes' time, we ascertained by means of a telephone that there was not another such motor in the community. The delay in sending to the manufacturer for a new end frame would mean an actual loss of hundreds of dollars.

We considered two ways of repairing the broken frame to keep the machine in service temporarily: One was to rivet on plates to hold the broken parts together, and the other was welding. We could get the parts aligned better by using patches, but it would not be as rigid a job as the weld. The break on the frame was, incidentally, on the end away from the pulley. Not only was the outside ring of the frame cracked through, but also the hub enclosing a bolt hole was broken out completely, as was the center hub housing the bearings.

We finally decided to try welding. We first welded the ring together and put in the bolt hub. Then we clamped the piece on a planer bed, blocked the center hub up on the inside on its machined face and ran a bolt down through to keep it in place. All of the welding was done from the outside. The bearing bushing and the oil ring had been removed, as had also the brush holder rigging.

In spite of the clamping, the center hub twisted somewhat when it cooled. This did not surprise us for we had noticed the same thing on other similar repair jobs. In such a case, there are two courses open in making a job that will have all the faces concentric and square. One is to bore out the center hub and make an oversized bushing for it—the frame being chucked in the lathe and trued up by the ring facing its inner shoulder. This is the method to use when the bore is badly out of line. It takes a longer time to do it, however, and requires a special bushing. The other method is to slip an arbor in the center hub, which is of the same size as the outside diameter of the bronze bushing, and to put this assembly on centers in the lathe. Then face the big end of the frame head and cut the inside shoulder to fit over the

main body of the frame—or inside of the main body of the frame, as the construction may be.

This is what we did in the case of the motor that had been broken. The surface on the big end of the frame end ran out of line ⅛ in. Using a lathe tool, we cut until this cleared up about two-thirds of the way around the frame. The inside of this frame was bored out in the same way, not taking out all of the untrue surface but enough of it to give an average bearing so as to properly align the end frame and prevent its being sprung by the bolts.

At the same time, two inside surfaces at the hub were cut back an equal amount so that the brushes would not bind, or the rotor be unable to float in its bearings as formerly. In a little less time than three hours, we had the motor going again, almost as good as ever, and working perfectly. Such a repair is comparatively inexpensive, it makes a good job, and it saves the day where the motor is the big machine, as it most generally is.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

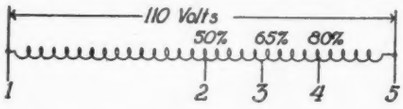
Method of Using an Autotransformer for Locating Grounds on Motors

WE HAVE found that the autotransformer from an old compensator or auto-starter can be used as a very convenient means of obtaining low voltages for testing for grounds in motors, controllers and the like. Most compensators have two or three coils placed in the same laminated frame. We use only one of these coils. This autotransformer was taken from a compensator having a rating of 5 or 10 hp., at 440 volts, although a 220-volt autotransformer could have been used. The higher-voltage transformer is preferred as it has a higher reactance and keeps the current drawn from the line to a lower value when the testing terminals are shorted, as when a ground is found.

The two line leads of the autotransformer are connected to the 110-volt supply as shown in the accompanying diagram. By connecting two test leads to the different taps of the coil, various low voltages can be obtained. Assuming that the autotransformer has a 50 per cent tap, a 65 per cent tap and an 80 per cent tap, and that the line leads of the coil are connected to a 110-volt power supply, the voltages shown in the table accompanying the diagram can be obtained.

In using the apparatus, the test leads are first connected across the tap giving the lowest voltage. The other end of one test lead is then grounded on the frame of the machine under test and the other lead connected to the winding. The ground will show up by an arc or smoke, for this method of testing permits a large current to flow through the defective part of the equipment tested. If nothing happens with the lowest voltage, the test leads may be moved to taps giving a higher voltage.

The advantage of this method over a test lamp is that the test lamp only indicates that a ground is present and does not locate its position, because the



To Obtain	Connect Test Leads to
16½ volts	Leads 2–3 or 3–4
22 volts	Leads 4–5
33 volts	Leads 2–4
38½ volts	Leads 3–5
55 volts	Leads 2–5 or 1–2
71½ volts	Leads 1–3
88 volts	Leads 1–4
110 volts	Leads 1–5

Test leads are connected to taps on the autotransformer, thus obtaining a low voltage for testing.

The voltage values that may be obtained with the taps indicated are shown in the table. This method of testing will pass enough current through a ground to cause it to arc or burn, thus showing its location.

resistance of the lamp is too high to permit much current to flow through the defect, while the autotransformer will deliver sufficient current to cause the ground to smoke or arc.

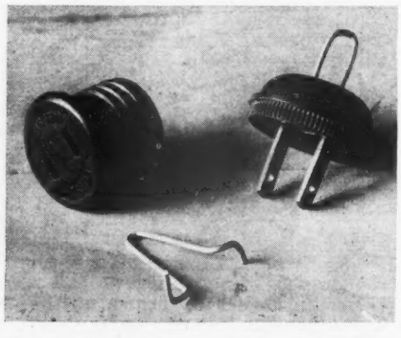
Chief Electrician, W. B. CONE.
Shevlin-Hixon Company,
Bend, Ore.

How to Make Simple and Easily Replaceable Fuses

IN RUNNING a test on some electrical equipment it was necessary to replace blown fuses as quickly as possible, and as no circuit breaker or renewable fuse was at hand, the outfit shown in the illustration was used as a substitute and worked very well. As will be seen, caps of separable attachment plugs were fitted with lengths of fuse wire bent as shown, and the plug itself placed in the fuse block. When the fuses blew they were immediately replaced by exchanging caps. Later on the caps were refilled at leisure.

While such a fuse would not, of course, be suitable for a permanent installation, it is very useful, in emergencies, in any repair shop or laboratory. Also, it is much cheaper than the ordinary plug fuse, as the fuse wire may be purchased cheaply in rolls and cut to the desired length.

Boulder, Colo. HAROLD E. BENSON.



Fuse wire of the desired rating is fastened under the terminals in the cap of a separable plug, which is screwed into the fuse block.

How to Clean Old Commutator Bars and Strap Copper Armature Coils

IN SMALL repair shops and winding departments of industrial plants occasions arise for removing the old insulation from a set of strap copper armature coils, or the old mica from between commutator bars, in order to reinsulate them or put in new mica.

The best way of removing the old insulation is to allow the coils or bars to soak from 4 hr. to 8 hr., depending upon their size, in a tank of boiling Wyandotte or Oakite cleaning solution. An ordinary water pail or wash-boiler, heated on a gas plate, may be used in the absence of a standard tank with steam coils, or other means of heating the cleaning solution.

Armature coils should be removed carefully from the armature, so as not to bend them out of shape, tied in bundles of five or ten depending on size, being lifted in and out of the tank by long pieces of scrap wire attached to each bundle. The coils should be soaked until the old insulation is soft and soggy like wet paper; then they may be removed a few at a time and the old insulation cleaned off while it is still wet. A stiff-bladed knife (one made from a power hacksaw blade will do) should be used. A scraping motion along one edge of the coil is all that will be necesary to remove the insulation. This procedure does not affect the tinning of the leads nor the copper itself, and is much better and quicker than burning off the old insulation. Burning makes the tinned ends glass-hard and warps the coils out of shape.

If the coils to be reinsulated are large and have mica and fishpaper cells in the slot sections, it is best to remove the wrappers before placing the coils in the cleaning bath. One good method of doing this is to run a glass cutter along the cell or use a sharp knife to cut along one edge and then untwist the old wrapper with the hands. It is not necessary to cut down to the copper; cut the tape and one turn of the wrapper, and then unwind the wrapper and tape. The reason for removing the cells is to allow the cleaning bath to get at the copper under the slot insulation and remove any old varnish or tape. It will be found that time can be saved by first removing the wrappers.

In the case of commutators the V-rings, mica and metal should be removed and the commutator knocked apart into a wire mesh basket. One or two pieces of mica should be saved as samples. The commutator bars should be allowed to soak in the hot cleaning solution until all the mica falls away from them. This will leave the copper clean and it will not be necessary to sandpaper any of the bars or scrape them with a knife to remove particles of mica and shellac.

A cleaning tank will be found useful for soaking small transformer cores, auto-starter cores, small d.c. armatures, with the commutator removed, to loosen up hard slot insulation and numerous other jobs around the shop.

Wilkinsburg, Pa. A. C. ROE.

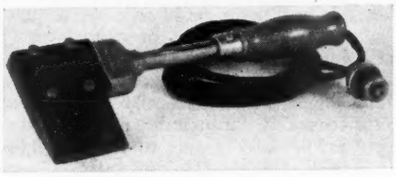
New Equipment

For Plant Operation and Maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Heavy-Duty Soldering Iron

THE electrically-heated soldering appliance shown in the illustration has been designed by Harold E. Trent, 259 North Lawrence St., Philadelphia, Pa., to meet heavy-duty requirements. It is made in two styles: a spear shape and a hatchet type. The latter is shown in the accompanying illustration. Both



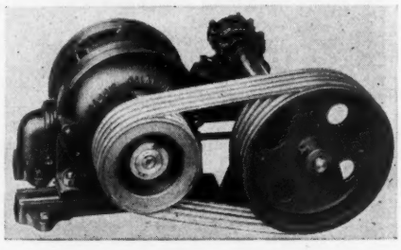
of these have a copper tip in which the heating unit is clamped and which, it is said, can be left on indefinitely at its rated voltage without overheating the tip or burning out the heating element.

The iron complete weighs 5¼ lb. and the tip is 3 in. wide by ¼ in. thick on its working surface. It has been so designed that the proportions are such as to make for easy handling. It is intended for use on 110-volt circuits and draws 500 watts.

Ten feet of the best grade of flexible cord with a two-part plug are provided to facilitate connections.

Short-Center Flexible Drive

DEVELOPMENT of a new type of short-center, flexible drive, known as the Texrope Drive, is announced by the Allis-Chalmers Mfg. Co., Milwaukee, Wis. The Texrope Drive, as shown in the accompanying illustration, consists of a pair of grooved sheaves and a number of special endless V-belts. These sheaves are far enough apart so that the belts fit the grooves, it is claimed, without tension, slack, or lost motion in the drive. Also, that due to the V construction, they cannot slip, as the harder they pull the more firmly the belt grips the groove; however, being elastic and stretchable they do not jerk either when starting or running, nor do they transmit vibrations, but act as cushions between the driving and the driven machines.

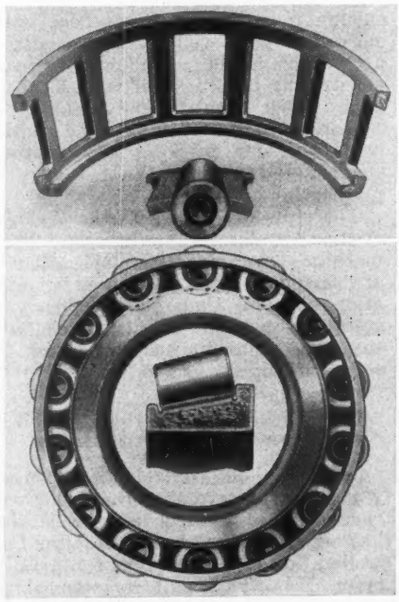


It is stated that bearing pressures are low, as no belt tension is necessary: also, that the drives occupy very little space, are silent, are unaffected by moisture or dirt, are safe and simple, and each belt carries its portion of the load.

With no slip the speed ratios are fixed. There are in use Texrope drives having ratings from ½ to 250 hp., with speed ratios, up to 7 to 1, and belt speeds ranging from 800 to 6,000 ft. per minute. They have already been placed in service in nearly every industry, particularly on textile machinery, fans and blowers, machine tools, food manufacturing machines, refrigeration, mining, crushing, wood and metal-working machinery, elevators and conveyors, paper, flour and rubber mill drives and on other appliances.

Improved Roller Bearings

ANNOUNCEMENT that an improved type of Timken tapered roller bearing is now in production is made by The Timken Roller Bearing Co., Canton, Ohio. This new bearing has



major refinements but retains all of the essential elements of the Timken bearing. It is made of nickel-molybdenum, special-formula steel. The design of the roller has been changed so that the surface of the large end presents a right-angle relation to the center line of the roll, as shown in the lower part of the accompanying illustrations. The contact between the large end of the roll and the riveted cone is in two areas. The rib of the cone is slightly undercut. This two-area contact is made to insure axial alignment between the center line of the roll and the center line of the bearing at all times. Another purpose served by the two-area contact is in maintaining alignment of the rolls on the cone in the cup, without resorting to a cage fixture to retain the alignment.

The Timken cage has been improved along with the cone and roller assembly in that all the cage pockets are made at one time by a multiple perforating die which perforates all roll pockets in the cage by a single impact. A section of cage is shown in the upper part of the accompanying illustration. Other refinements have been made in the manufacturing processes, to prevent distortion of the parts. These improvements are said to have reduced the noise made by the bearings while in operation.

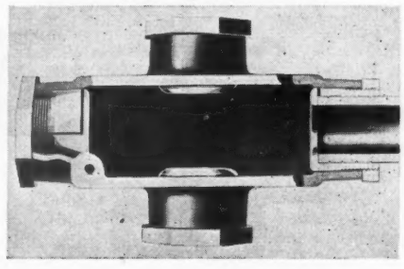
Heavy-Duty, ¼-in. Drill

THE line of portable electric tools manufactured by The Black & Decker Mfg. Co., Towson, Md., has been increased by the addition of a heavy-duty, ¼-in. drill. This model is not intended to take the place of the ¼-in. drill which has long been on the market but has been designed to supplement it. The two drills are similar in general appearance, but the heavy-duty tool is built for more severe service and operates at a higher spindle speed than the regular model.

The 3,000 r.p.m. motor can be operated on either a.c. or d.c., 110-volt current. Additional ventilating holes are contained in the rear of the motor housing. The trigger switch is used.

Threadless Conduit Fittings

A LINE of threadless conduit fittings known as Emico Kondu-Box has been put on the market by the Erie Malleable Iron Co., Erie, Pa. The Emico Kondu-Box does not require any threads on the conduit, although it can be used on either threaded or unthreaded sections. By the use of this threadless fitting the cost of thread cutting is entirely eliminated and in addition the cost of erecting or putting the conduit in place is said to be reduced owing to the fact that it is unnecessary to screw the conduit into the fitting. This box is so designed that every connection or outlet is a union in itself, which eliminates the use of running threads or units, and permits construction to be started at any point



without resorting to a running thread. As these fittings are made of malleable iron they are claimed to be non-breakable.

The construction and method of installation of these boxes may be easily seen from the accompanying illustration. The slotted bushing which is tightened down on the conduit has rings on the interior which are forced through the enamel of the conduit as the locknut is tightened on the bushing and so make a metallic contact between the conduit and the box.

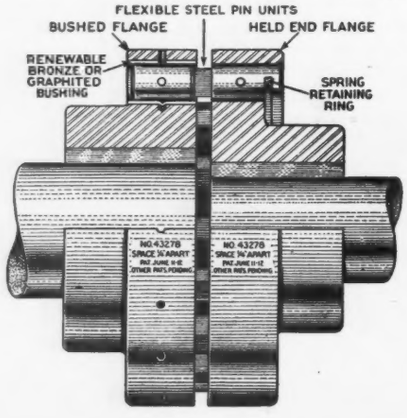
Any fitting may be removed from an installation after it has been completed so that another Kondu-Box with more openings may be substituted, without breaking the fitting. It is also unnecessary to use right- and left-hand threads, and lengths of conduit bent to any shape may be fastened together because it is unnecessary to turn the conduit in the fittings.

Another feature of these boxes is that it is impossible to lose the cover screws, as these are retained in the cover screw openings, although free to turn. In addition to the line of conduit boxes there is also a complete line of threadless couplings and adaptors for use with standard steel knockout boxes.

Improved Flexible Coupling

ANNOUNCEMENT is made of the introduction of a line of improved Francke flexible couplings for motor, turbine and engine drives, by Smith & Serrell, 26 Washington Place, Newark, N. J. These couplings will be known as the bushed-pin type in which the steel pin units are held in bronze bushings but are free to slide within these bushings.

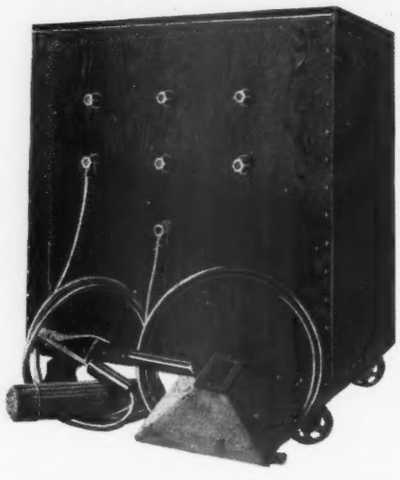
This improved Francke coupling retains many of the features of the old, heavy pattern type and has several new features which, it is claimed, give more and easier movement, increased capacity, and longer life at all speeds. Steel flanges are used for the small and intermediate sizes. Graphited bronze bushings are used in size No. 850 and larger and bronze bushings in smaller sizes are removably locked in one flange. The steel pin units are free to slide ½ in. within the bushings. It is claimed that in this way contact surfaces are more than doubled, a cylindrical surface is obtained, movement is between steel and bronze, and the graphited bushings present a self-lubricating surface that retains its lubricating qualities.



These couplings will be made in 21 regular sizes, rating from 2/3 hp. per 100 r.p.m., at 4,000 r.p.m. maximum, up to 3,850 hp. per 100 r.p.m., at 490 r.p.m. maximum, and for shafts from ¾ in. in diameter up to 13 in. in diameter.

Combination Type Arc Welder

DEVELOPMENT of a welding outfit which permits the use of both the continuous and the intermittent arc has been announced by the Electric Welding Machine Co., 1530 E. Larned St., Detroit, Mich. It is claimed



that with this combination unit the operator can obtain a continuous arc, such as is supplied by the motor-generator type of welder, for use in operations on steel and metal that is heavy enough to withstand great heat without cracking, as well as an intermittent arc, which is claimed to have greater penetrating qualities but with localized heat which permits the welding of cast-iron, hard malleable, and chilled iron, without cracking the castings welded, and without the necessity of pre-heating.

The units are known as the Weldrite electric welding machines. These machines are made for operation at any frequency and, if desired, for operation at more than one frequency or voltage, for use in plants which have, say, 220 volts in one part and 440 volts in another.

New Hoist Controller

A NEW hoist-control unit, consisting of a reversing controller with rope-operated control master station, has been developed by the Monitor Controller Co., 500 E. Lombard St., Baltimore, Md. This unit is intended for use on traveling cranes, chain and rope hoists, or similar applications requiring a compact and substantial unit possessing desirable safety features. The equipment is of standardized design and is intended for operation on direct-current and on polyphase alternating-current motors that are thrown across the line for starting.

The controller consists of two enclosed-type, double-pole, mechanically-interlocked contactors having graphite-to-copper contacts, blowout magnets and suitable barriers, all mounted on an 8-in. by 7-in. panel. The overall dimensions of the controller are 8½ in. by 10½ in. by 6 in. deep.

The control master is of the fully-enclosed, self-centering type and intended for rope operation. It is always in the "off" position, except when held forcibly by the operator in either "forward" or "reverse" position. Bosses cast on the station housing take the pull of the operating rope, and protect the contacts from any mechanical damage.

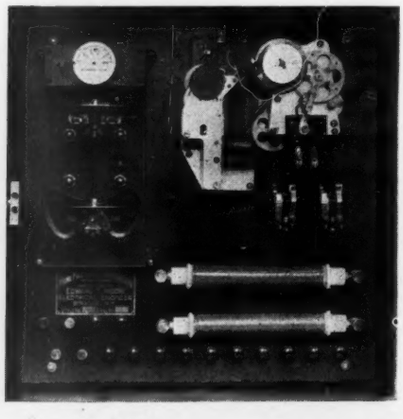
Power Demand Limitator

A NEW model of the Edmoore Demand Limitator, which is an electrically-operated device for automatically controlling maximum demands and peak loads on electric power systems, has been brought out by Edward C. Moore, Consulting Engineer, 500 Cahill Bldg., Syracuse, N. Y. This equipment automatically limits any unnecessary, unusual, or short-time power peak demands and is especially valuable where the charge for peaks drawn on "readiness to serve" is such a large fixed charge of the total power bill.

This automatic device may be set for different peak demands at different hours of the day, so as not to conflict with central station peak power demands. It is connected in the power system to cut off certain loads automatically, either wholly or in part, for short periods of time, so as to keep the demand within the limit.

The Senior Type, Model 1-A Limitator, shown in the accompanying illustration, has a wattmeter element which is connected to the current and potential transformers at the point where the power is metered on the consumer's premises, and an electromagnetic mechanism, which is actuated periodically, depending upon the period of the demand, by a set of contacts mounted in the standard totalizing watt-hour meter. It is stated that one installation used in connection with electric furnaces is saving $2,000 per month.

These power limitators may be used to control pump loads, air compressor loads, refrigerating machinery loads, heating furnace loads, melting furnace loads, and so on.



Trade Literature

That You Should Be Familiar With

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Action Recorder—A series of bulletins describe the use of the Service Recorder for recording the operating and idle time of machinery, yard locomotives, tractors, trucks, and so on.—The Service Recorder Co., Cleveland, Ohio.

Megohmer—Bulletin B describes the use of the Megohmer for measuring insulation resistance of motors, generators, and other equipment.—Herman H. Sticht & Co., 19 Park Row, New York City.

Carbon Circuit Breakers — Circular 1705-A describes the Type CL carbon circuit breaker which is designed especially for 250-volt industrial applications.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Automatic Compensators—Bulletin 1042-E describes the line of E. C. & M. automatic compensators for automatically starting push-button operated, squirrel-cage induction motors. These are made in four standard sizes covering a wide range of motor sizes.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Portable Belt Conveyor—A group of folders describes a line of portable belt conveyors and self-feeding bucket loaders for handling, elevating, or loading loose material.—Barber-Greene Co., Aurora, Ill.

Flexible Shaft Couplings—A circular describes the Bartlett flexible shaft coupling which allows for parallel misalignment, angular misalignment, and end float.—G. M. Bartlett, 2533 College Ave., Indianapolis, Ind.

Pulling Jack—A 16-page circular illustrates a large number of uses of the Pullmco pulling jack which, it is claimed, does the work of lifting jacks, chain hoists, winches, blocks and tackle for moving heavy machinery and other weights up to 100 tons. It may be operated at six different speeds.—Puller Manufacturing Co., Inc., 600 W. 57th St., New York City, N. Y.

Wound-Rotor Induction Motors—Circular GEA-5 covers the 500 Series of wound-rotor induction motors of 10 to 150 hp. at 220, 440, 550 and 2,200 volts, for constant or adjustable varying speed and the types of control systems used therewith.—General Electric Co., Schenectady, N. Y.

Portable Hot-Job Fans—A circular describes the 24-in., 30-in. and 36-in. portable, man-cooling disk fans for cooling operators on hot jobs and for preventing hot air pockets.—B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Outdoor Insulating Tape—A circular describes and gives the advantages claimed for Hydro-proof tape in making splices. This tape is made of cotton sheeting which is coated with a sticky, hydro-carbon composition containing no rubber and is claimed to be rainproof and also not to dry out when subjected to hot sunshine.—Elkhart Rubber Works, Elkhart, Ind.

Acetylene Welding—A 16-page booklet entitled "Precautions and Safe Practices" covers the care and operation of acetylene welding and cutting equipment and the handling of oxygen and acetylene, as recommended by the National Safety Council and the National Board of Fire Underwriters.—Oxweld Acetylene Co., Long Island City, N. Y.

Self-Cooled Transformers—Bulletin 2046 describes the Pittsburgh film-type radiator for self-cooled transformers. — Pittsburgh Transformer Co., Pittsburgh, Pa.

Speed Recording and Indicating Instruments—Bulletin 725 describes and illustrates the Esterline-Angus speed recorder. This consists of a fully-enclosed, magneto-type generator, which generates a voltage directly proportional to the speed of rotation, and a direct-current recording voltmeter. — The Esterline-Angus Co., Indianapolis, Ind.

Safety Set Collars—A circular describes the Rex safety set collars, which are made from malleable iron in both solid or split types.—Chain Belt Co., Milwaukee, Wis.

Exhaust Fans—Bulletin 3506 describes a line of steel-plate exhaust fans which are especially adapted for removing shavings, sawdust, dust from grinding and buffing wheels, for conveying material, elevating cotton, wool, hemp, and grains, for the removal of smoke and fumes, and other similar purposes.—American Blower Co., Detroit, Mich.

Twin Type Recorder—Form 925 shows the type of double record which may be made simultaneously on a single sheet by a Twin Type recorder.—The Esterline-Angus Co., Indianapolis, Ind.

Wiping Out—or Washing?—Folder 83 under this heading discusses the value of the Thompson safety lowering switch for lighting fixtures.—The Thompson Electric Co., 1438 W. 9th St., Cleveland, Ohio.

Asphalt Paint—A circular describes the use of Valdura asphalt paint as a preservative. — American Asphalt Paint Co., 844 Rush St., Chicago, Ill.

Metal-Insulated Ovens—A circular describes the line of No-thru metal-insulated ovens for core baking, mold drying, japanning and other similar services. These ovens are made from standardized steel panels and parts which can be arranged so that the ovens can be made in increments of 1 ft. in width up to 10 ft., in height up to 10 ft., and of any depth. These may be heated by gas or oil or electricity.—The Northern Blower Co., W. 65th St. and Wheeling & Lake Erie R. R., Cleveland, Ohio.

Pressure Regulators—Bulletin 200 A illustrates and describes the line of Standard Type R oxygen regulators and also regulators and gages for gas lines for welding outfits.—The Alexander Milburn Co., 1416-1428 W. Baltimore St., Baltimore, Md.

Safety Hand Lamps and Hand Lanterns—Folder 29 and Bulletin 2081 illustrate and describe a number of types of safety hand lamps and hand lanterns for use around inflammable gases, vapors and so on.—Crouse-Hinds Co., Syracuse, N. Y.

Gravity Conveyors—Circulars describe a special type of ball-bearing roller conveyor which is constructed to stand up under all conditions and especially under heavy loads.—Standard Conveyor Co., North St. Paul, Minn.

Welding and Cutting Equipment—Catalog 6 devotes 54 pages to listing and describing the various Smith's welding and cutting apparatus and outfits, acetylene generating units and attachments and oil preheating torches.—Smith's Inventions, Inc., 2619-33 4th St., S. E., Minneapolis, Minn.

Steel Belt—Circulars describe the use of Endural endless steel belts for power transmission drives and for conveyors. These belts are made endless at the factory and are of light gage, rustless and stainless alloy. It is claimed that the edge of the belt will not cut.—The Power Engineering Co., Youngstown, Ohio.

Cutless Bearing—A circular describes the Goodrich cutless bearing which consists of a rubber-lined bearing with a helical internal groove through which water is forced. No other lubricant is required. These bearings are used in very wet places, such as in paper mills.—The Goodrich Rubber Co., Akron, Ohio.

Belt Shifters—A circular describes the Builders pull countershaft and Universal belt shifters. With this device the belt is shifted either to tight or loose pulley by pulling a small rope. —Builders Iron Foundry, 9 Codding St., Providence, Rhode Island.

Steel-Taped Cable—A 24-page booklet describes the construction, and gives specifications and other data about steel-taped parkway cable for underground transmission.—The Okonite Co., Passaic, N. J.

Indicating and Recording Instruments—Catalog 44 describes Brown indicating and recording tachometers. Catalog 74 describes Brown recording pressure and vacuum gages.—The Brown Instrument Co., Philadelphia, Pa.

Leather Belting—A booklet entitled, "Pre-Tested Leather Belting," discusses what pre-tested leather belting means to the buyer of belting and gives some of the tests made.—Chicago Belting Co., 113-125 N. Green St., Chicago, Ill.

Bus Supports and Disconnecting Switches—Bulletin B covers a line of indoor bus supports; Bulletin C, indoor disconnecting switches; and Bulletin D, outdoor bus supports.

This equipment is for use on lines operating at 7,500 to 132,000 volts.—The Champion Switch Co., 550 Abbott Road, Buffalo, N. Y.

Belt Fastener—A circular describes the Standard self-aligning belt fastener which has special nibs which fit into the belt in such a way as to align the fastener properly ready for riveting.—The Bourne-Fuller Co., Unionville, Conn.

Inductive Time Limit Controller—Publication C-24 illustrates and describes various installations of this controller which it is claimed eliminates the use of dashpots and other mechanical means for securing uniform acceleration.—The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Dust Arresters—A group of bulletins describe the Norblo dust arrester and dust collecting systems for foundries, pattern shops, woodworking mills and for use in connection with the pneumatic conveying of materials.—The Northern Blower Co., W. 65th St. and Wheeling & Lake Erie R. R., Cleveland, Ohio.

Centrifugal Pumps—Bulletin 201 describes the single-stage, double-suction centrifugal pump. Bulletin 202 describes the single-stage, single-suction, heavy-duty centrifugal pump such as is used for handling pulp stock in paper mills and other similar lines.—Warren Steam Pump Co., Warren, Mass.

Constant-Speed D.C. Motors—Circular GEA-61 describes the Type CD, 40-deg., constant-speed, direct-current motors of 3 to 200 hp. rating, which are four-pole, shunt or compound wound, for 115, 230 or 550 volts, and the types of manual or magnetic control used with them.—General Electric Co., Schenectady, N. Y.

Power Elevating Platform Trucks—A circular describes a light-weight, power-driven, elevating platform truck which uses only one motor for propelling and also for lifting the load. The truck platform is low and of a size which enables it to be used in connection with hand-lift truck skids. — Wright-Hibbard Industrial Electric Truck Co., Inc., Phelps, N. Y.

Underground Cable Boxes—Circulars describe the Type C box which is submersion-proof and is designed for high-tension underground primaries.—The G. & W. Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Air Compressor—A group of bulletins describes the Pennsylvania portable, semi-portable and stationary air compressors, vacuum pumps and after-coolers. These compressors may be belt or engine driven, or direct connected to electric motors.—Pennsylvania Pump & Compressor Co., Easton, Pa.

Installation Tools—A circular describes four Jiffy tools for use in electrical installation work. These are: The Jiffy dipper, ceiling cutter, adjustable cutter and loom clamp.—Paul W. Koch & Co., 23 S. Wells St., Chicago.

Oil Circuit Breakers—Circular 67448-A, Class 2, describes FK-1 and FK-12-B, single-, double-, triple-, or four-pole, single-throw oil circuit breakers for use where service is severe. All types are available for manual, solenoid, or motor operation and may be either automatic or non-automatic. These circuit breakers are made for 4,500 volts, 1,500 amp., for 22,000 volt 300 amp., and for 15,000 volts at 300, 500 and 800 amp.—General Electric Co., Schenectady, N. Y.

Easily Repairable Valve—A circular describes the Flatplug valve which is so designed that the cup and seat may be easily removed and replaced with spare parts and the worn parts reground.—Scully Steel & Iron Co., 24th St. and Ashland Ave., Chicago.

Automatic Shut-off Acetylene Torches—A circular describes the Rego automatic shut-off torch which saves gas by enabling the operator to shut off the torch and light it again instantly without readjusting the valve.—The Bastian-Blessing Co., 240 E. Ontario St., Chicago, Ill.

Bearing Metal—A circular describes the advantages of Utility bearing metal for high-speed operation which, it is claimed, has a low coefficient of friction and can be heated to a cherry red without damage.—The Hill Pump Valve Co., 4601-27 Belmont Ave., Chicago, Ill.

Automatic Speed Control—A 28-page, well illustrated bulletin, 108, describes automatic equipment for the control of newspaper and magazine printing presses and paper calenders.—Monitor Controller Co., 500 E. Lombard St., Baltimore, Md.

E M F Electrical Year Book Sold to McGraw-Hill Company

MC GRAW-HILL Company has purchased the *E M F Electrical Year Book* published by the Electrical Trade Publishing Co., Monadnock Block, Chicago. The 1926 edition, which will be out April 1, 1926, will be edited by the staff of the Electrical Trade Publishing Co. and sold by the staffs of both organizations. Headquarters for the Year Book until completion of the 1926 edition will be at the offices of the Electrical Trade Publishing Co. in Chicago, but information and data may be secured from men of both organizations.

This standard reference book will supplement the service of McGraw-Hill electrical publications by supplying the reference information needed by buyers and specifiers throughout the industry.

Other McGraw-Hill reference publications are, *McGraw Central Station Directory*, *McGraw Electric Railway Directory* and *The Radio Trade Directory*. It is planned to extend the directory and list services into other industries now served by McGraw-Hill publications.

Robert Wolfers has joined the McGraw-Hill Company and will be in charge of directories, lists and a direct-mail department which is being developed to serve McGraw-Hill advertisers.

Mr. Wolfers was formerly connected with *The Automobile Trade Directory* and *Chilton Automobile Directory*.

Mr. J. S. Cortelyou who has for the past year been devoting his time to *The Radio Trade Directory* will in the future direct the compilation of all McGraw-Hill directories and lists. Mr. Cortelyou was associated for many years with Mr. Wolfers in the automotive directory business.

Re-Entrancy in Lap and Wave Windings

(Continued from page 583)

lead pitch is an odd number (9). The series of coils starts on bar *1* and goes through coil *A* to bar *10*, coil *J*, to bar *19*, or two behind the bar started on. Following the winding out we will encircle the armature twice and end up on bar *1* after passing through all of the coils. Thus we have two windings that are interconnected, and singly re-entrant as can be seen.

From the above and a study of Figs. 3 and 4 we can derive the following rules that apply to duplex wave windings:

(1) The total number of bars for a 4-pole winding must be divisible by 2; for a six-pole winding, the number of bars $\pm$ 2 must be divisible by 3; for eight poles the number of bars $\pm$ 2 must be divisible by 4, etc.

(2) The winding will be progressive when the plus sign is used, and retrogressive when the minus sign is used.

(3) A 4-pole winding can be either progressive or retrogressive, but for six, eight, ten poles, and so on, the plus or minus sign will be the deciding factor.

In all cases, regardless of the number of poles, the winding will be singly re-entrant when the lead pitch expressed in bars is an odd number, as 9, 11, 13, etc. The winding will be doubly re-entrant when the lead pitch, in bars, is an even number, as 8, 10, 12, etc.

From the above it follows that a singly re-entrant winding is one in which all of the coils are passed through in regular sequence before the winding closes on itself, and a doubly re-entrant winding is one in which the winding closes on itself after passing through one half the coils, as may be noted in this case, thus forming two separate windings which are not interconnected in any way.

In taking rewinding data for duplex wave windings the winder can determine whether the winding is progressive or retrogressive by selecting any one top lead and lifting two top leads on either side of this lead bar. Then with one test lead on the data lead bar, try for a light on bars *1* and *3*, to the right or left. If the third bar to the right lights out, the winding is progressive. If the third bar to the left lights out, the winding is retrogressive. By checking the lead pitch in bars, the re-entrancy of the winding can also be determined without difficulty as already explained.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as The Electrical Review

December, 1925

McGraw-Hill Co., Inc. Chicago, Ill.

Timkens in Motors

NOW your electric power costs can come close to the bare kilowatt rate. Most maintenance items are killed by Timken Tapered Roller Bearings on motor shafts. Timken load area, high thrust capacity, positive roll alignment, and steel-to-steel rolling motion end the wear which drops the rotor dangerously.

Timken-equipped motors run for months at least without added lubricant. Timken-equipped motors are more compact. And they work perfectly in all motor positions.

In plants where cost work is most vigilant, and in industries which are "death to motors," Timken-equipped motors are giving the best account of themselves.

THE TIMKEN ROLLER BEARING CO., *CANTON, OHIO*

TIMKEN *Tapered Roller* **BEARINGS**

More Advancements from ALLIS-CHALMERS

Again Allis-Chalmers notably advances electric motor development. With the introduction of a series of induction motors equipped with Timken tapered roller bearings, the Allis-Chalmers line emphasizes its position of progressive leadership.

In these new motors more compact and more rigid design is possible. Full speed is reached with uniform and rapid acceleration, all the motion being *ROLLING* motion. And with a very small percentage of ordinary lubrication and inspection requirements the correct initial spacing of rotor and stator is permanently maintained. There is unprecedented endurance for any form of drive. And whatever the position required, lubrication is unaffected. Even the cooling vents are better placed because of the compactness of the bearing housings.

In fact, from the easier starting characteristics, to the reduced shaft overhang, a host of major improvements are added to established Allis-Chalmers excellence in design, operation and maintenance.

Commercial installations under rigorous conditions have returned astonishing data—a veritable education in modern motor economy. Write for literature or make an immediate personal appointment through the nearest Allis-Chalmers office.

ALLIS-CHALMERS MANUFACTURING CO., Milwaukee
District Sales Offices in all Principal Cities

Contents for December, 1925

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

G. A. VAN BRUNT, *Managing Editor*

Volume 83 *Number 12*

Are You a Bloodhound or a Setter? 557

Using Oils and Greases for Industrial Lubrication 558

In this article, which is the first of a series, oils and greases are discussed from the standpoints of what they are, how they are prepared and factors that influence their selection and application.

Using a Graphic Meter for Setting Overload Relays 564

G. A. Sharland describes how a graphic ammeter is used by the Minnesota By-Products Coke Co., in setting overload and accelerating relays on motor controllers.

Some of the Maintenance Problems in the Small Plant 567

Maurice C. Cockshott discusses problems that have a particular bearing on production and gives suggestions on how they may be solved with a small organization.

Reducing Heat Loss from Electric Baking Ovens 573

C. D. Corwin tells how a saving of $2,200 a year was made by reinsulating four japan baking ovens in the plant of the Corona Typewriter Co.

Practical Advice on Brush and Commutator Maintenance 575

E. S. Howe discusses some of the more important factors that influence commutation, with the causes of trouble and the remedies therefor.

What Re-Entrancy Means in Lap and Wave Windings 582

A. C. Roe gives some examples and simple rules governing the relations and principles involved in connecting singly and doubly re-entrant windings.

Editorials 584
Questions Asked and Answered 586
Electrical Service Around the Works 594
Mechanical Maintenance of Power Drives 597
In the Repair Shop 599
New Equipment 601
Trade Literature 603

Advertising Index—Alphabetical, 92; Classified, 86 Maintenance Service, 39; Searchlight Section, 84

A New Service Given to Our Readers

IN RESPONSE to many requests, a New Equipment section has been added to the editorial pages of INDUSTRIAL ENGINEER. In this section, which will be found on page 601 of this issue, there will be presented descriptions and illustrations of new equipment which is of interest to our readers.

This new form of service is in addition to the Trade Literature section, which will be conducted as heretofore, and in which a brief description is given of all new catalogs and literature covering equipment of interest to industrial plant men.

Editorially, INDUSTRIAL ENGINEER is wrapped around the thinking and the practical details of the problems encountered by those who bear the responsibility of selecting, installing, operating and maintaining the electrical and mechanical equipment in mills and factories, regardless of the product made. It is the function of INDUSTRIAL ENGINEER to help and serve these men in every possible way to solve the many perplexing problems which come up in their work, day after day.

To this end the Editors will heartily welcome any suggestions or comments which readers may care to make regarding subjects for articles, special features, or any other form of service that would be interesting and helpful to them in a practical way.—*Managing Editor.*

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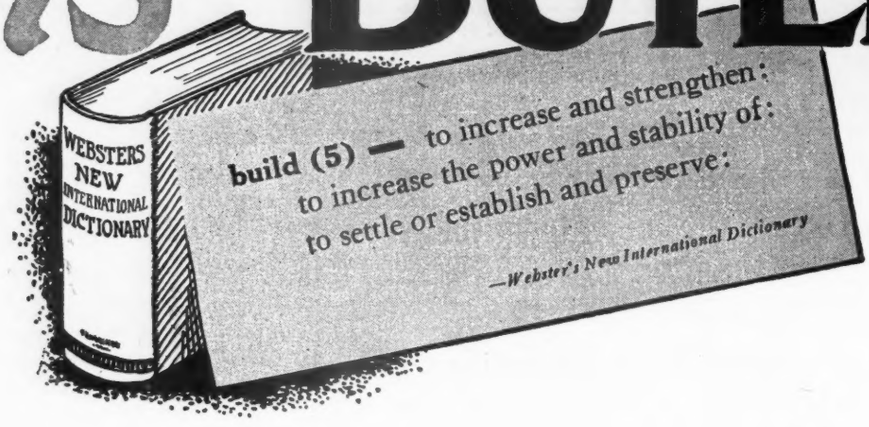
Industrial Engineer (Published in Chicago)

American Machinist—European Edition

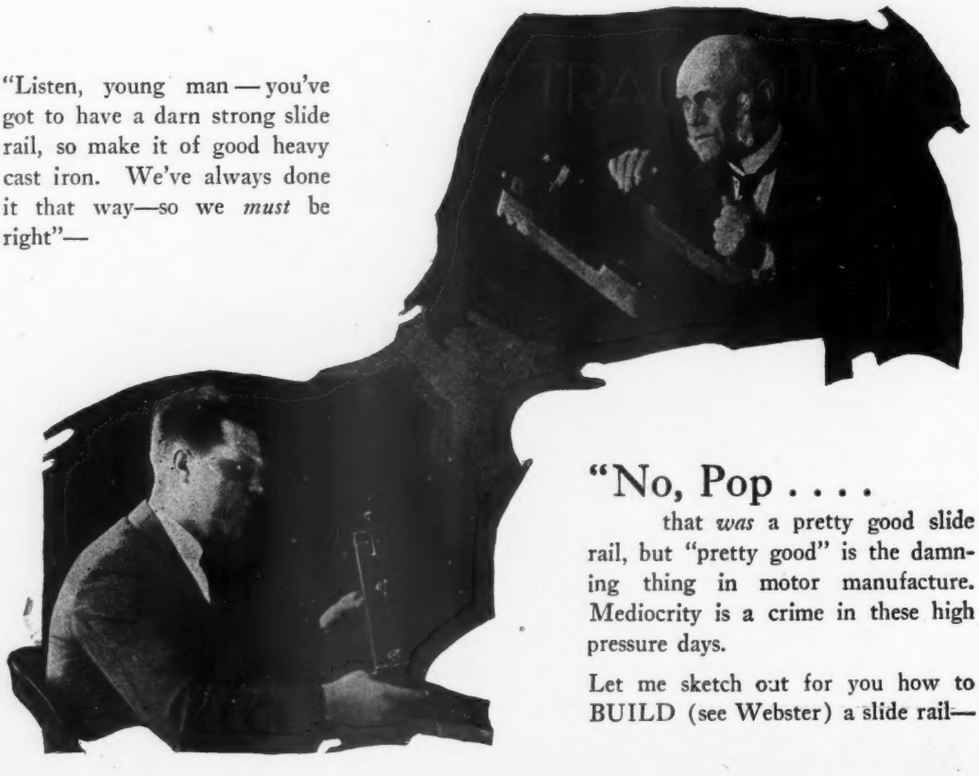
The annual subscription is $2 to any part of the United States, Canada, Mexico, Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba, Honduras, Nicaragua, Peru, Colombia, Bolivia, Dominican Republic, Panama, El Salvadore, Argentine, Brazil, Spain, Uruguay, Costa Rica, Ecuador, Guatemala, Paraguay and Chili. Extra postage to other countries, $1 (total $3, or 13 shillings). Single copy, 25 cents. Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Copyright, 1925, by McGraw-Hill Company, Inc. Published monthly. Entered as second-class matter Nov. 7, 1903, at the Post Office at Chicago, under act of March 3, 1879.

Let's BUILD



How shall we make the slide rails?

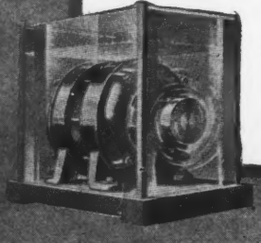
"Listen, young man — you've got to have a darn strong slide rail, so make it of good heavy cast iron. We've always done it that way—so we *must* be right"—



"No, Pop . . . .

that *was* a pretty good slide rail, but "pretty good" is the damning thing in motor manufacture. Mediocrity is a crime in these high pressure days.

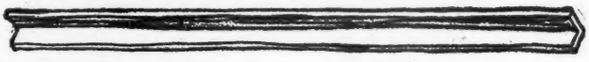
Let me sketch out for you how to BUILD (see Webster) a slide rail—



LINC-

a motor!

You take a piece of angle steel—

so: 

and you saw it up—

so:

and you put it together—

so:

and by this highly developed *process* known as STABLE-ARC welding you have a solid piece of angle steel that, compared with your cast iron, is—

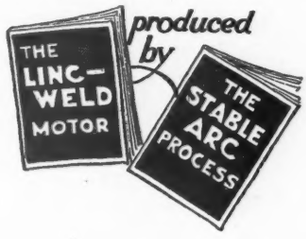
5 times as strong in tension
Twice as strong in stiffness !
One-third the cost per pound •

Let's put the money we save on this into higher cost insulation, so that we'll have it on competition without cost to the motor buyer.

You've been too much *sot* on castings for everything. Get the bulletin from Lincoln Electric showing how many thousands of articles have been, or can be, made cheaper, stronger and better by the stable arc process—the Linc-Weld motor being an outstanding example.

Illustrated answers

Realizing that the news value of the new process motor, as well as the process by which it is constructed, will naturally bring up many questions—two very completely illustrated volumes have been prepared thoroughly covering the subjects:



These books are in envelopes ready to be sent by return mail to all persons requesting them.

For your convenience in getting your copies—simply pencil in your address on the coupon below.

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Cleveland, Ohio

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To The Lincoln Electric Co., Cleveland, Ohio

Please send to Mr. .....

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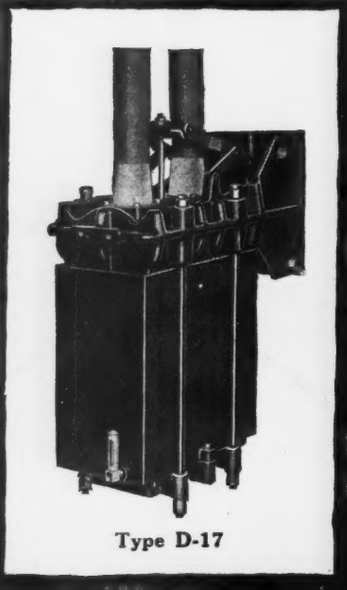
The Motor Book ☐
The Stable Arc Process Book ☐

Energy Absorption



Type D-17

When railroad trains clank over the rail joints, the spring suspension of the heavy car bodies takes up the shock—protects trucks, track and freight from danger—safeguards passengers and crew from discomfort and danger.

And when the CONDIT D-17 Oil Circuit Breaker opens a high power circuit it's the *spring suspension* of its tank construction that takes up the impact of expanding gases—protects the breaker from impairment—safeguards life and property, and the service of your plant, from possible hazard. Get Advance Bulletin No. 4453.

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Manufacturers of Electrical Protective Devices
BOSTON, MASS

Northern Electric Company LIMITED

Sole Distributor for the Dominion of Canada

SPECIFICATIONS: 1, 2, 3 and 4 Pole; Manually and Electrically Operated; up to 1,600 Amperes, 7500 Volts; 1,200 Amperes, 15,000 Volts; 600 Amperes, 25,000 Volts. Interrupting capacity, 6,000 Amperes at 15,000 Volts.

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The new narrow center
Hyatt Line Shaft Box
stocked by these dealers

Arkansas—Hollis & Co., Little Rock.

California—Shaw-Palmer-Bakewell Co., Los Angeles.

Connecticut—L. L. Ensworth & Sons Co., Hartford.
C. S. Mersick & Co., New Haven.
Hotchkiss & Co., Waterbury.

Georgia—The Grinnell Co., Atlanta.

Illinois—R. R. Street & Co., Inc., Chicago.

Indiana—Evansville Supply Co., Evansville.
Vonnegut Machinery Co., Indianapolis.

Iowa—Iowa Machinery & Supply Co., Des Moines.

Kentucky—E. D. Morton & Co., Louisville.

Louisiana—R. J. Tricon Co., New Orleans.

Maine—Simpson Harding Co., Waterville.

Maryland—L. A. Benson Co., Inc., Baltimore.
Foltz Mfg. & Supply Co., Hagerstown.

Massachusetts—Lewis E. Tracy Co., Boston.
Olmsted-Flint Co., Cambridge.
Babbitt Steam Specialty Co., New Bedford.
W. J. Foss Co., Springfield.
F. I. Webster, Turners Falls.
G & N Machine Co., Worcester

Michigan—Palmer-Bee Co., Detroit.

Minnesota—Northern Machinery Co., Minneapolis.

Missouri—English Bros. Mach. Co., Kansas City.
Colcord-Wright Mach. & Supply Co., St. Louis.

New Jersey—The Lincoln Products Corp., Newark.
New Jersey Eng. & Supply Co., Passaic.
Manufacturers' Selling Co., Trenton.

New York—Peerless Mill Supply Co., Buffalo.
J. P. Jones, Binghamton.
Horton Machine Works, Elmira.
Clark Hardware Co., Jamestown.
W. L. Smith, Newburg.
Albert H. Robbins, New York City.
Tiffany Machine Shop Co., Poughkeepsie.
Barr & Creelman Mill & Plumbing Supply Co., Rochester.
Syracuse Supply Co., Syracuse.
Troy Belting & Supply Co., Troy.

North Carolina—Charlotte Supply Co., Charlotte.

Ohio—Wm. S. Yohe Supply Co., Canton.
Mechanical Supplies Co., Cincinnati.
Ohio—Strong, Carlisle & Hammond Co., Cleveland.
Ross Willoughby Co., Columbus.
M. D. Larkin Supply Co., Dayton.
M. I, Wilcox Co., Toledo.

Oregon—Link Belt Co., Portland.
Pacific States Rubber Co., Portland.

Pennsylvania—The H. P. Weller Supply Co., Erie.
James Yocum & Son, Inc., Philadelphia.
Tranter Mfg. Co., Pittsburgh.
Bright & Co., Reading.
Valley Iron Works, Williamsport.

Rhode Island—New England Sales Co., Inc., Providence.

Tennessee—Tennessee Mill & Mine Supply Co., Knoxville.

Texas—Hardwicke-Etter Co., Sherman.

Virginia—James McGraw, Inc., Richmond.

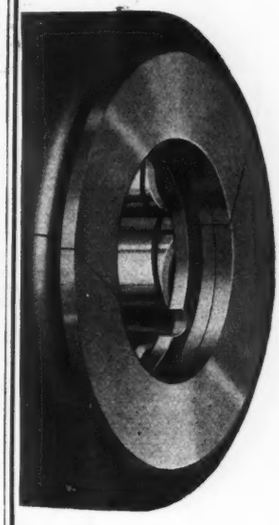
Washington—Brinkley Co., Seattle.

Wisconsin—C. A. Biebler, Milwaukee.

Canada—Canadian Fairbanks-Morse Co., Calgary, Alberta.
Canadian Fairbanks-Morse Co., Victoria, B. C.
A. R. Williams, Halifax, N. S.
Canadian Fairbanks-Morse Co., Hamilton, Ontario.
Canadian Fairbanks-Morse Co., Montreal, Quebec.
Williams & Wilson, Ltd., Montreal, Quebec.
A. R. Williams, Montreal, Quebec.
Canadian Fairbanks-Morse Co., Ottawa, Ontario.
Canadian Fairbanks-Morse Co., St. Catherines, P. E. I.
A. R. Williams, St. John, N. B.
Canadian Fairbanks-Morse Co., Toronto, Ontario.
H. W. Petrie, Ltd., Toronto, Ontario.
A. R. Williams Machinery & Supply Co., Toronto, Ontario.
Canadian Fairbanks-Morse Co., Windsor, Ontario.
J. T. Wing, Ltd., Windsor, Ontario.
Canadian Fairbanks-Morse Co., Winnipeg, Manitoba.

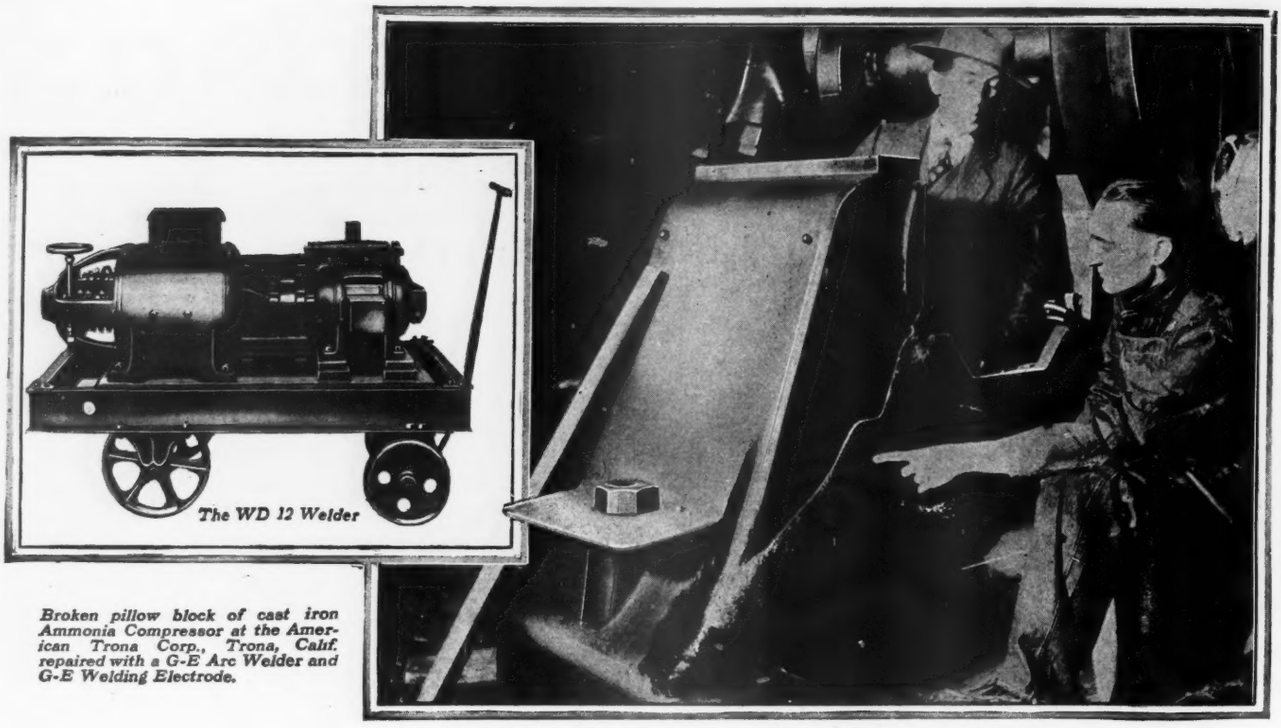
Japan—T. Fukahara Shoten, Osaka

England—Hyatt Limited, London.



HYATT
ROLLER BEARINGS

The NEW Hyatt line shaft box fits all makes of hangers. Being SPLIT, its installation does not require disturbing pulleys and other shafting equipment.



Broken pillow block of cast iron Ammonia Compressor at the American Trona Corp., Trona, Calif. repaired with a G-E Arc Welder and G-E Welding Electrode.

G-E Arc Welders Save Costly Delays and New Parts

An eight-foot crack—but G-E arc welding repaired it. The job took hours, instead of days or weeks, as would be the case if a new pillow block had to be secured and installed. And, when mended, the weld possessed greater strength than the compressor body.

Arc welding for repairs and emergency construction work eliminates costly delays and prevents dangerous risks. That corroded or worn place on boiler, retort, or pressure vessel can be patched immediately; leaking joints or cracked seams can be mended; a caulking, leak-proof deposit can be welded along the edge of riveted seams.

Speed and Simplicity are favorite characteristics of the G-E Arc Welder. Current is adjusted to suit the work by simply turning a hand-wheel. A reactor automatically steadies the arc. There are many to testify that a G-E Arc Welder soon pays for itself.

The Welding Specialist in your nearest G-E office can advise you.

The G-E line of Arc Welders includes types for all purposes. If you have standardized repetition work in joining or building up surfaces, investigate the G-E Automatic. It is the most economical, most efficient method.

23-15

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL PRINCIPAL CITIES

A new home for B-B Brushes and better service for users

The long wearing, non-heating, non-scoring Boxill-Bruel Carbon Brush will hereafter be made in our new plant at North Bend, Ohio. This move from Indianapolis gives us better manufacturing facilities, which will reflect in the improved service, quality, and lower costs to all.

If your carbon brushes are giving you any cause for dissatisfaction, send for samples of Boxill-Bruel Brushes, together with data sheet and catalog. You will be agreeably surprised at the results you will obtain from our brushes.

BOXILL-BRUEL CARBON CO.

NORTH BEND, OHIO

(Cincinnati is near us)

Through the scale of industry with

Tycos INSTRUMENTS

A series of advertisements showing the wide range of application of *Tycos* Instruments throughout the field of modern industry.

Precision the Keynote of Chemical Manufacturers *demands Tycos Control*

Where physical and chemical purity of product is vital to successful marketing, "rule of thumb" methods have long since given way to technology in process control.

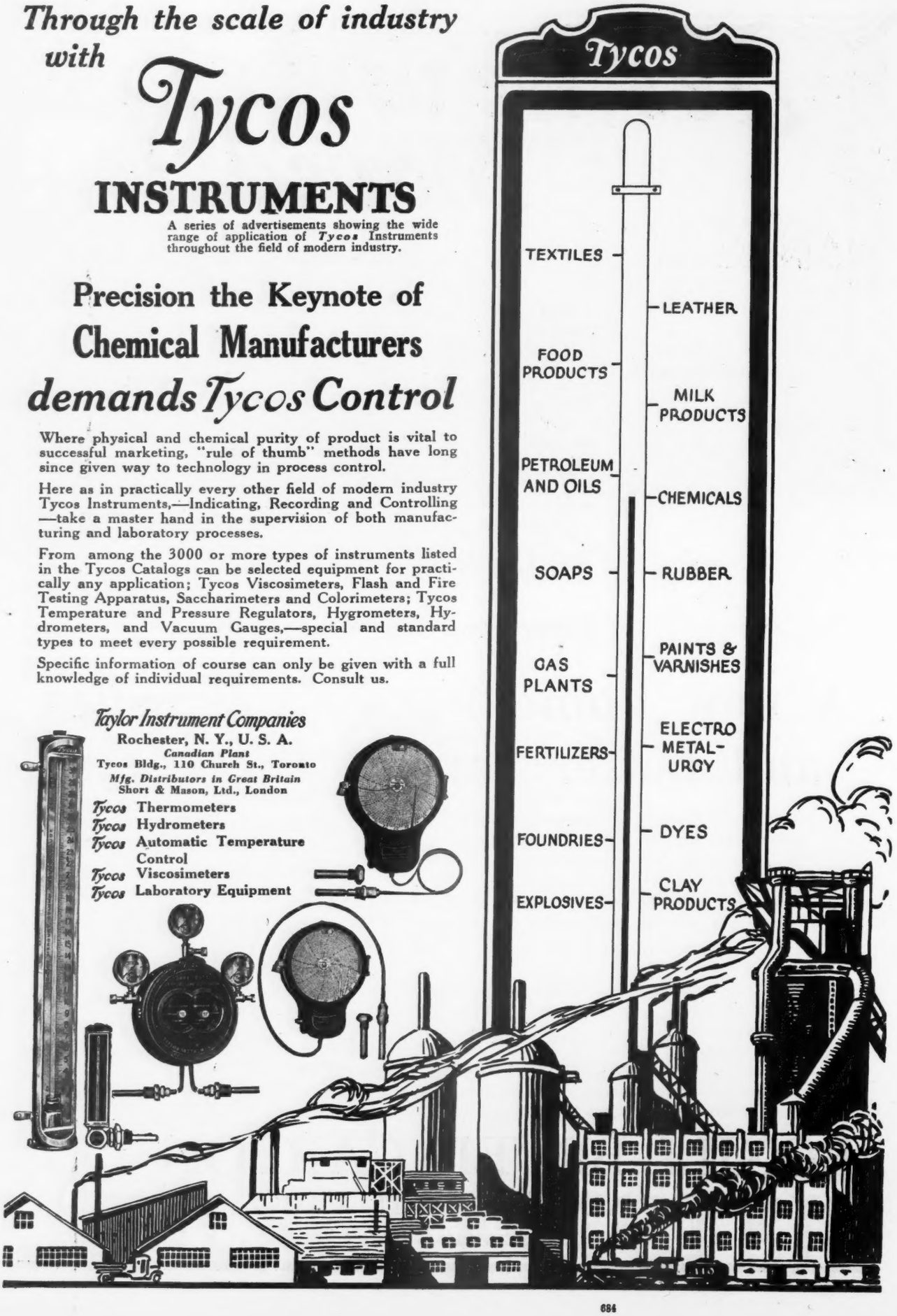
Here as in practically every other field of modern industry Tycos Instruments,—Indicating, Recording and Controlling —take a master hand in the supervision of both manufacturing and laboratory processes.

From among the 3000 or more types of instruments listed in the Tycos Catalogs can be selected equipment for practically any application; Tycos Viscosimeters, Flash and Fire Testing Apparatus, Saccharimeters and Colorimeters; Tycos Temperature and Pressure Regulators, Hygrometers, Hydrometers, and Vacuum Gauges,—special and standard types to meet every possible requirement.

Specific information of course can only be given with a full knowledge of individual requirements. Consult us.

Taylor Instrument Companies
Rochester, N. Y., U. S. A.
Canadian Plant
Tycos Bldg., 110 Church St., Toronto
Mfg. Distributors in Great Britain
Short & Mason, Ltd., London

Tycos Thermometers
Tycos Hydrometers
Tycos Automatic Temperature Control
Tycos Viscosimeters
Tycos Laboratory Equipment



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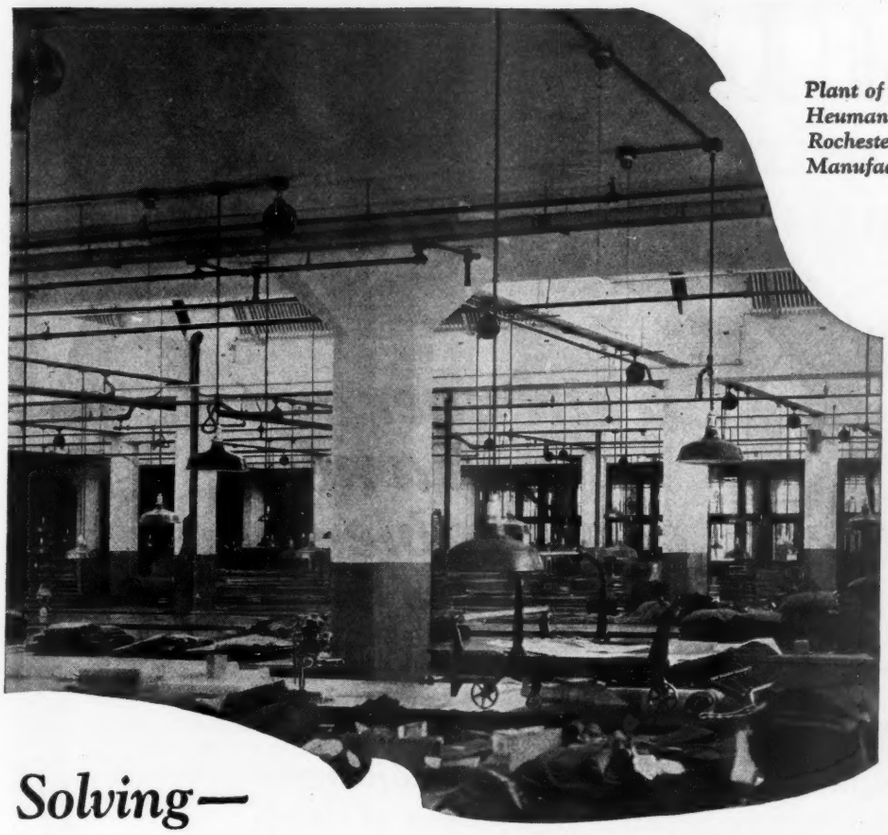
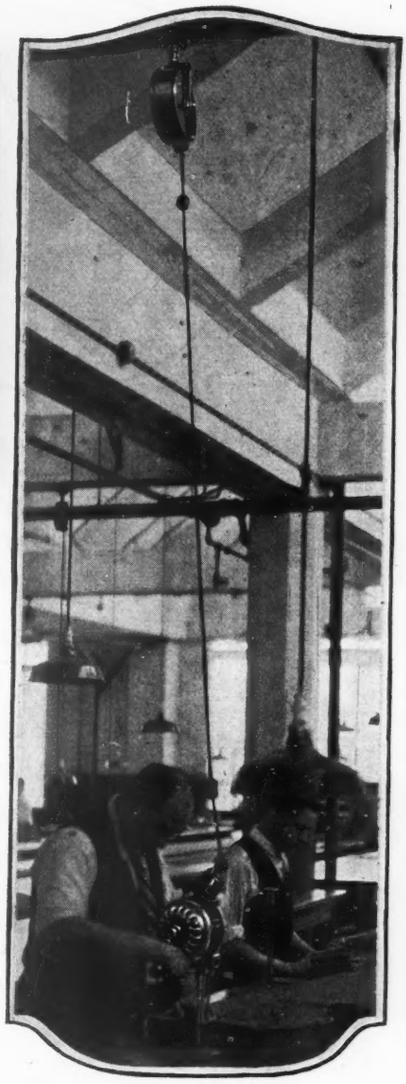


Plant of Keller, Heumann & Thompson, Rochester, N. Y., Manufacturers of Clothing



Solving— another power and light problem

REELITE speeds up the work at the cutting tables in the clothing industry because the cords carrying the current to the cutters do not drag the fabrics and are always clean and without kinks.

Reelite permits a far greater range of usefulness for portable tools, lights, etc., as the reel holds more cord than is practicable otherwise.

Instantaneous, smooth return of cord—out of the way when not in use. Your factory can use Reelite profitably. Write for information to the

APPLETON ELECTRIC COMPANY
1718 Wellington Avenue
CHICAGO, U. S. A.

NEW YORK
265 Canal Street

LOS ANGELES
340 Azusa Street

The Reelite shown here is similar to Reelite No. 1524 equipped with 24 ft. No. 18-2 conductor Junior Super-service cord. Spring tension very light, cord stop also very light, being made of fibre. Outlet box cover of the swivel type gives even greater freedom of action to the cord and tool.

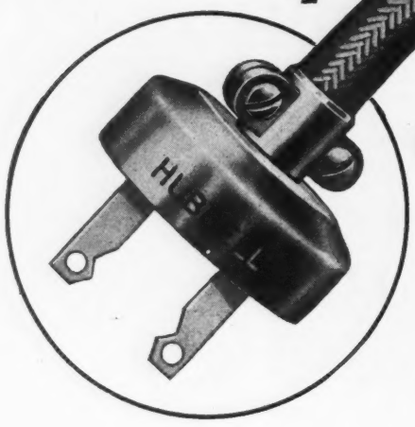
Reelite

REG. U. S. PAT. OFF.

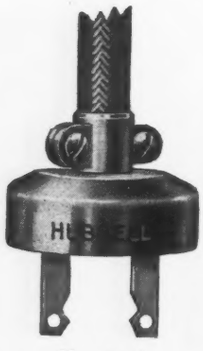
Carries Current Where Needed

HUBBELL

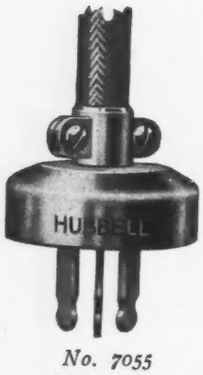
Clamp Strain Relief Caps



A stronger cap with a new adjustable— clamp feature



No. 7056
Two-wire



No. 7055
Three-wire

Completely steel-armored. *Adjustable* clamp feature permits adjustment of clamp to accommodate cords of various sizes.

Takes the strain off the binding posts. Prevents plug cap breakage.

For motors, electric appliances, portable electric machinery, trouble lamps, Bell signal systems, grounding systems, portable telephones, and many other purposes.

Ask your electrical supply house for complete information and prices.

HARVEY HUBBELL INC
ELECTRICAL WIRING DEVICES
BRIDGEPORT CONN. U.S.A.
NEW YORK, N.Y. CHICAGO, ILL.

ELECTRICAL WIRING DEVICES

American Steel & Wire Company

VARNISHED CAMBRIC CABLE

FROM the west windows of our New York offices you get a full view of the beautiful New York Telephone Building.

The fact that a product of the American Steel & Wire Company is used in this building makes the outlook unusually interesting.

Varnished Cambric Cable, the product used to a considerable extent, was selected after careful consideration and upon the recommendation of many users. In the process of selecting a cable, the contractors received our heartiest co-operation.

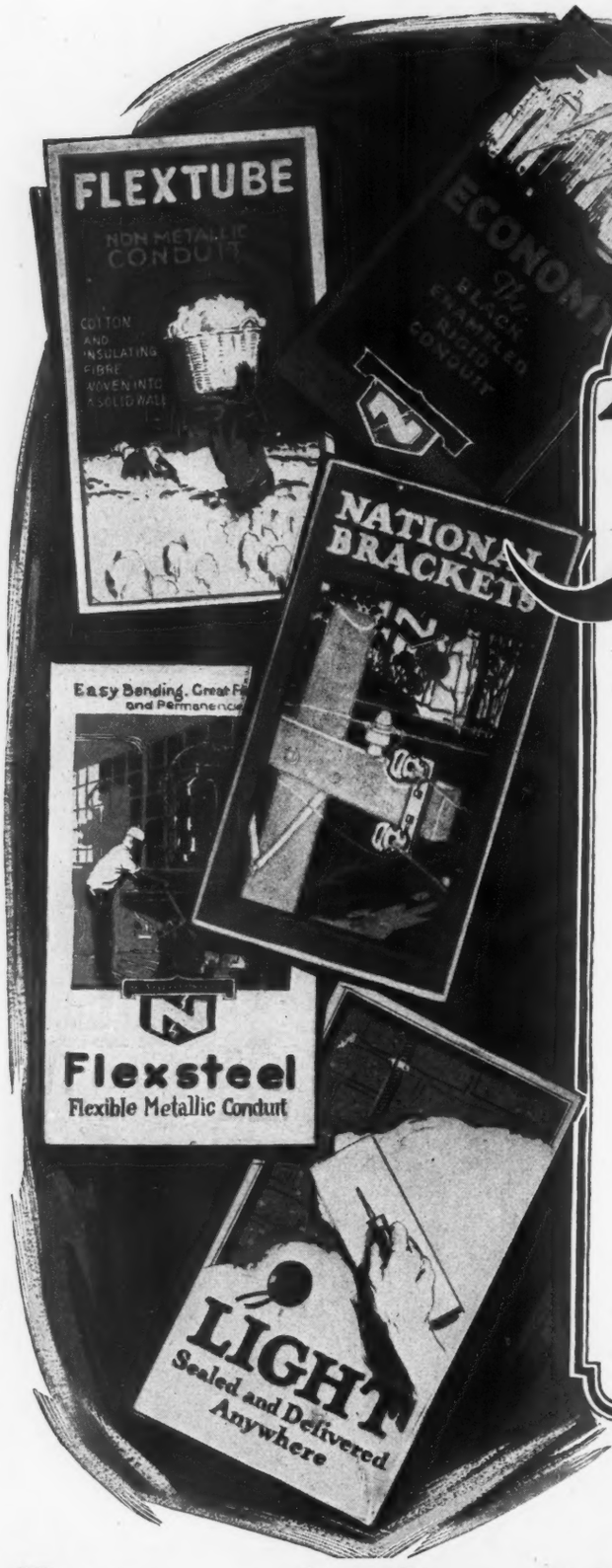
The price of Varnished Cambric Cable is always right. We invite your inquiry for prices on any quantity, for any voltage and for any service condition.

Catalog on request

MADE BY

AMERICAN STEEL & WIRE COMPANY

CHICAGO, NEW YORK, BOSTON,
BIRMINGHAM, DALLAS, DENVER, SALT LAKE CITY
U. S. STEEL PRODUCTS CO.: SAN FRANCISCO,
LOS ANGELES, PORTLAND, SEATTLE



5 FREE booklets

MAKING Conduits, Cables, and Fittings, for safe, permanent and trouble-free electrical wiring is the sole business of the National Metal Molding Company. Five of the products are fully and completely described in these booklets. Send for them.

ECONOMY Black Enameled Rigid Conduit, protected by double-dipped, acid-resisting coating of enamel—baked on.

FLEXTUBE Non-metallic, solid-wall Conduit. Never kinks! Bend it, jerk it, twist it, easily works back into shape again. The soap-stoned interior makes fishing easy.

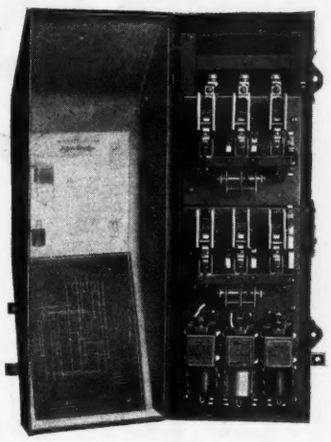
FLEXSTEEL Flexible Metallic Conduit, pliant as a rope of woven steel! Designed to withstand weather and moisture. Of great flexibility and permanence. Full line of sizes.

OVALFLEX A Flat Armored Cable only 5/16" thick. Bends edgewise and flatwise. Lay it on brick, tile or concrete without cutting or chipping and plaster right over it.

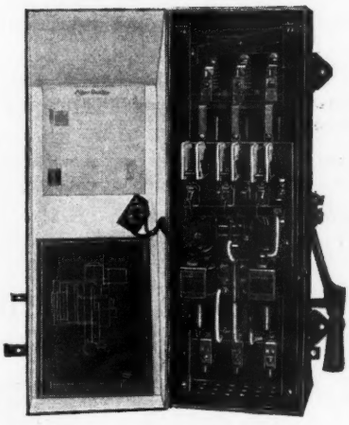
NATIONAL BRACKETS Designed so that wires can be attached or threaded and built to withstand excessive strain.

National Metal Molding Company
1581 FULTON BUILDING
PITTSBURGH, PA.
Represented in All Principal Cities (146

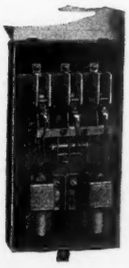
National Metal Molding Company



A single set screw adjusts the J-3052 Starter after installation to give desired rate of acceleration on every job.



The hand lever of the H-1852 Semi-Automatic Starter gives the operator complete control over the acceleration of squirrel-cage motors.



The J-1552 Across-the-Line Starter provides protection and convenience in starting.

Violent Starting Destroys Belts and Bearings

THE scientific selection of starters to fit machines rather than merely in accordance with motor ratings, reduces the wear and tear on belts and machinery. Accurate adjustment of starters after installation materially aids in securing economical and efficient performance.

Allen-Bradley Resistance Starters are easily adjusted to fit machines after installation. They provide smooth, gradual acceleration, which is not possible with compensators. They afford protection against overload, low-voltage, etc. They cost less than compensators.

Allen-Bradley Resistance Starters are revolutionizing motor starting. You should know about them. Mail the coupon!

Allen-Bradley Co.

ELECTRIC CONTROLLING APPARATUS

Baltimore	Cincinnati	Detroit	New York	Saint Louis
Birmingham	Chicago	Knoxville	Omaha	Saint Paul
Boston	Cleveland	Los Angeles	Philadelphia	San Francisco
Buffalo	Denver	Milwaukee	Pittsburgh	Seattle

ALLEN-BRADLEY COMPANY, General Offices
491 Clinton Street, Milwaukee, Wisconsin

Gentlemen:

Of course I want to know about the most effective methods for starting squirrel-cage motors. Please forward your catalog.

Name.....

Address.....

Okonite Tapes

Splice once and for all

WHY waste time and money trying to make permanent joints with inferior tapes?

With OKONITE TAPES you make splices *once and for all* which will be as strong electrically and as long-lived as the insulation on the wire itself.

Ask about OKONITE TAPE, the rubber insulating tape made with the same high grade rubber, compounding ingredients, and care that characterizes OKONITE insulation.

MANSON TAPE, the rubber filled cloth tape for the Mechanical protection of joints, is unequalled in weathering quality and supreme for any service where the best is the first consideration.

DUNDEE "A" and "B" TAPES, the next best friction tapes on the market, are suitable where conditions do not warrant the extra expense of Manson.

Write to our nearest Office for Samples and Booklet

The Okonite Company

The Okonite-Callender Cable Company, Inc.

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Sales Offices: New York · Chicago · Pittsburgh · St. Louis
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Novelty Electric Co., Phila., Pa. Pettingell-Andrews Co., Boston, Mass.
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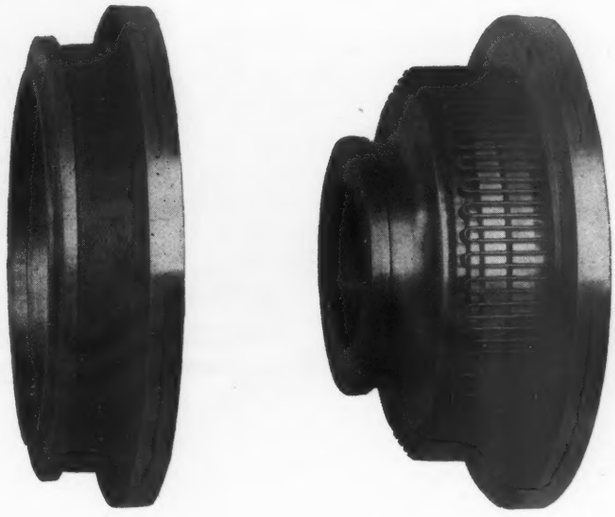
Cuban Representatives: Victor G. Mendoza Co., Havana



Somewhere in Your Plant—

Somewhere in your plant there is a coupling which is not giving all the power it should, which is wearing prematurely or which is constantly breaking. The Falk-Bibby Coupling has shown remarkable efficiency under even the most trying conditions and, because of its perfect lubrication, is practically free from wear.

The greater the shocks, the more irregular the load, the more frequent the vibration, the more this coupling demonstrates its great superiority.

Write to us for information.

The Falk Corporation, Milwaukee

Representatives

New York City—M. P. Fillingham, 50 Church Street
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Detroit—Chas. C. Walsh, Real Estate Exchange Bldg.
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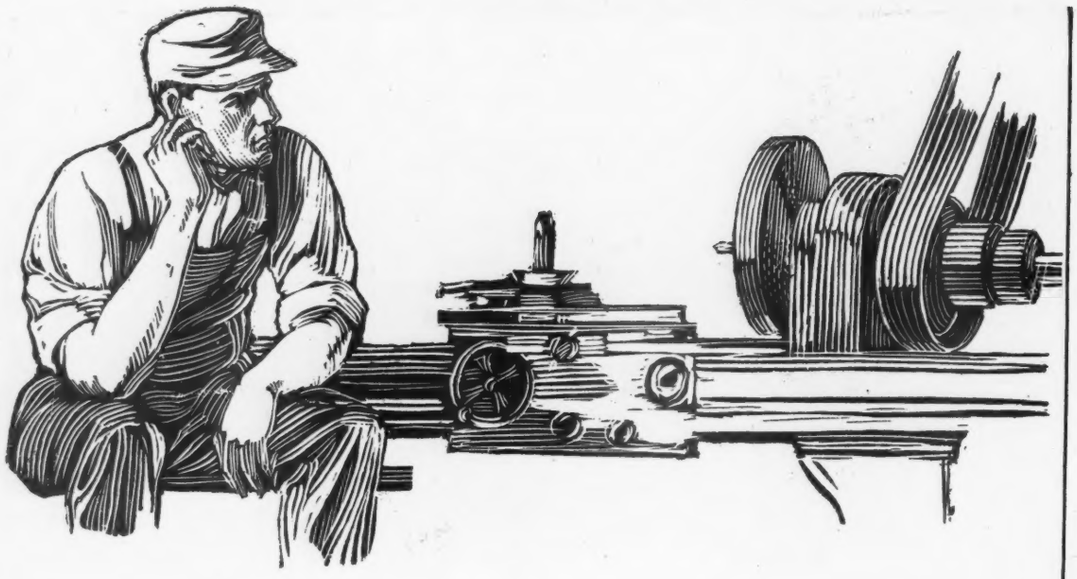
Bulletins FREE on Request

No. 31—Falk Herringbone Gears
No. 32—Large Gear Units
No. 38—Small speed reducers
No. 35—Falk-Bibby Flexible Couplings

FALK



Shutdowns are holdups

LIKE the sneaking bandit who, posing as the paymaster's guard, treacherously seizes the payroll, so inferior fuses, through failure to protect the circuits they are supposed to safeguard, hold up production and often necessitate direct expense far greater than would have been the cost of using dependable NOARK Fuses.

NOARK Fuses protect and promote production, safeguard motors and lighting circuits, insure freedom from overload hazards, never blowing prematurely. They blow when—*and only when*—the circuit is menaced with real danger. That is why NOARK Fuses are known as the fuses that blow "on the dot." And because of that dependable, accurate operation, NOARK Fuses are the safest and least expensive fuses you can use.

NOARK

NOARK fuses blow on the dot
NOT TOO SOON—NOT TOO LATE

The Johns-Pratt Company

HARTFORD, CONNECTICUT, U.S.A.

Division of Colt's Patent Fire Arms Mfg. Company

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TRADE MARK
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TRADE MARK
PROTECTION SERVICE JP
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J-P

has the ability and capacity to serve you in NINE ways

1 NOARK Fuses

2 NOARK Fuse Clips and Bases

3 NOARK Service Boxes

4 NOARK Underground Boxes

5 NOARK Universal Service Entrance Switches

6 Railway and mine material, hangers, insulators, etc.

7 J-P molding service—contract basis

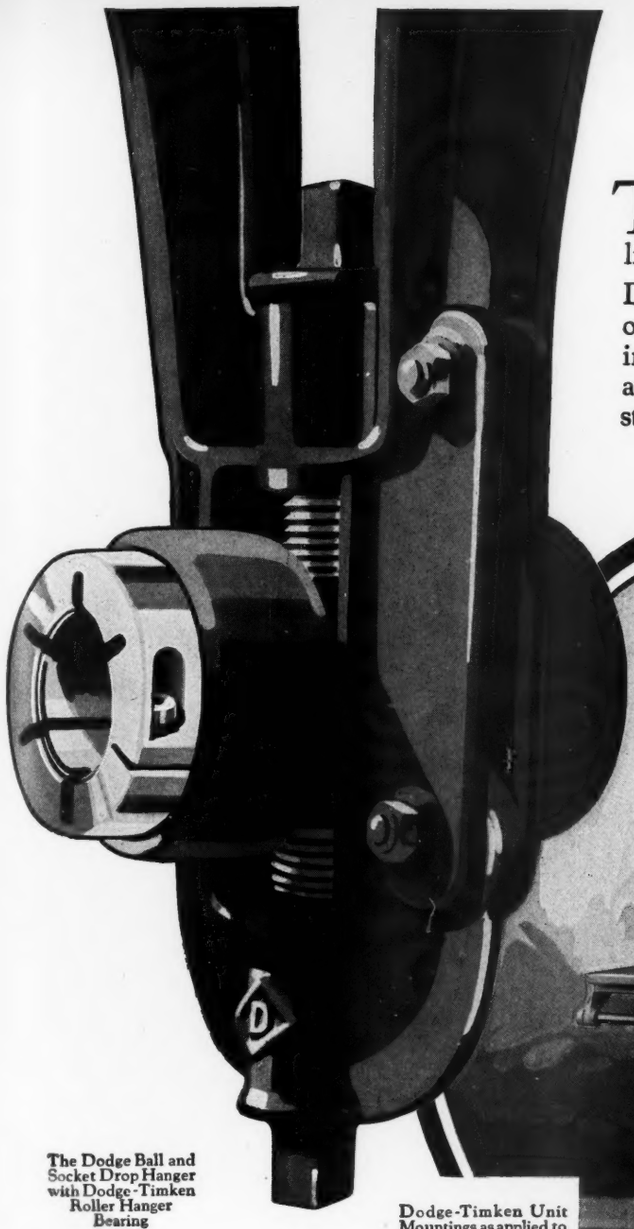
8 VULCABESTON Packing—sheet, rope, braided

9 J-P molded radio parts—from stock

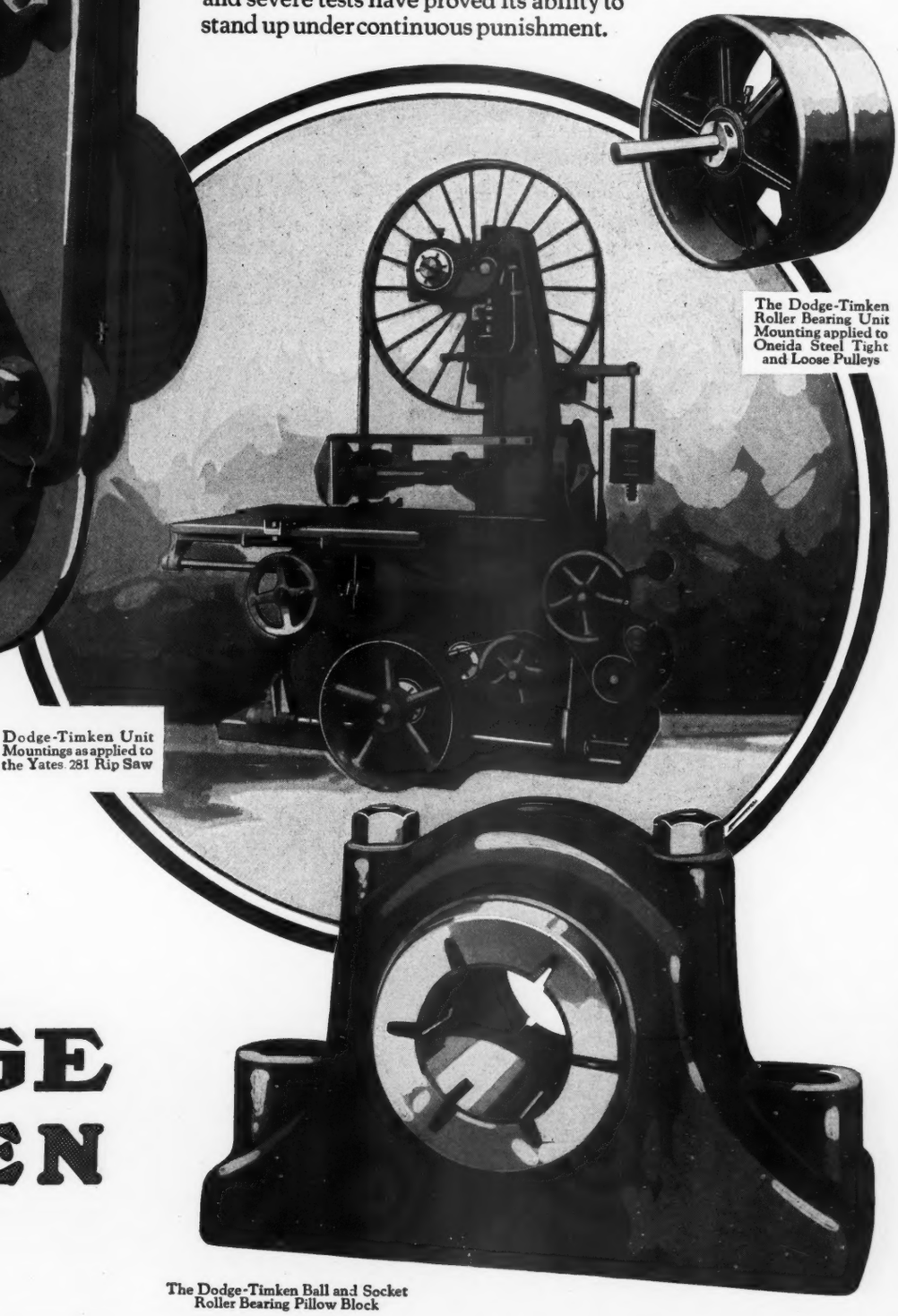
Rugged

THIS one word means more to you in terms of power savings, satisfactory, continuous operation and long life than volumes of technical description.

Dodge engineers have placed their unqualified approval on the Timken Tapered Roller Bearing as incorporated in Dodge-Timken Industrial applications because long and severe tests have proved its ability to stand up under continuous punishment.



The Dodge Ball and Socket Drop Hanger with Dodge-Timken Roller Hanger Bearing



The Dodge-Timken Roller Bearing Unit Mounting applied to Oneida Steel Tight and Loose Pulleys

Dodge-Timken Unit Mountings as applied to the Yates 281 Rip Saw

The Dodge-Timken Ball and Socket Roller Bearing Pillow Block

DODGE TIMKEN

POWER TRANSMITTING – ELEVATING – CONVEYING & SPECIAL MACHINERY

Applying the Roller Bearing to
INDUSTRIAL DEMANDS

THE endorsement of the Timken Tapered Roller Bearing for industrial applications by Dodge engineers followed the result of years of study of various types of low friction bearings under the severe conditions imposed by power transmitting and industrial service.

The Dodge-Timken Roller Hanger Bearing, which has proved every original claim in America's leading industrial plants, was followed by the Dodge-Timken Roller Bearing Pillow Block and the Dodge-Timken Tight and Loose Pulley.

The Dodge-Timken Standardized Unit Mountings for built-in applications to duplicate machinery is a further logical step in the development of a complete line of standardized low friction industrial bearings. The unit mounting permits the use of Timken Tapered Roller Bearings in duplicate machinery at a minimum engineering and production cost.

Every Dodge-Timken product is characterized by the ruggedness that means continuous power savings, trouble-free operation and long life.

Send for this complete catalogue

DODGE MANUFACTURING CORPORATION
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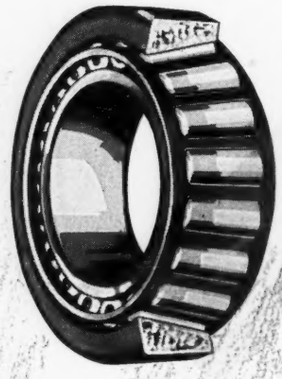

Dodge-Timken Roller Hanger Bearing

DODGE TIMKEN

CONVEYING AND SPECIAL MACHINERY

ELECTRICAL HEAT IN ITS MOST ADAPTABLE FORM

Now—A Better Space Heater —and at a lower price!

C-H

The C-H trademark has been a guarantee of satisfaction for more than a quarter of a century. Look for it on your new Space Heaters.

$2.00 List price East of the Rockies

SPACE heaters are the ideal solution for *hundreds of different heating problems*—their convenience, adaptability, and heating efficiency are ever widening their field of usefulness.

Now, Cutler-Hammer engineers have designed an improved space heater to meet this growing demand—improved in design and heating efficiency, *and lower in price!*

Just two feet long and easily installed, C-H Space Heaters put the heat just where it's wanted, in just the quantity that's wanted—for they may be used singly, in pairs or in groups, as required. Wherever clean, safe heat is needed—in crane cabs, watchman's houses sump pits, exposed rooms, drying and japanning ovens, detached buildings—C-H Space Heaters are the most practical and economical to use. They are ideal for foot warmers, and for innumerable other applications. Users are discovering new applications every day.

Improved design and construction throughout make the new C-H Space Heater a better heating unit. Simpler provision has been devised for installation and the resistance coil is filled with and embedded in a new refractory material which provides for better insulation of the element and quicker radiation of the heat.

One hundred and twenty-five typical applications of space heaters have been worked into a little booklet—"Dictionary of Uses". Every man in industry will find it profitable reading. Send for your copy today.

THE CUTLER-HAMMER MFG. CO.

Works: Milwaukee and New York

Branch Offices:

New York: 8 West 40th Street
Chicago: 323 North Michigan Avenue
Pittsburgh: Century Building
Philadelphia: Commonwealth Building
Cleveland: Guardian Building
Boston: 52 Chauncy Street
Detroit: 506 Hofman Building
St. Louis: 2111 Railway Exchange Bldg.
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Inquiries from the Pacific Coast may be directed to the H. B. Squires Co., Los Angeles, San Francisco, Portland, Seattle

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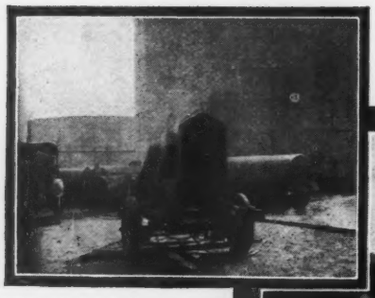


Both illustrations show Super Service Welding Cable at the Albany Welding, Boiler and Machine Shop.

Vulcanized in steel molds under tons of pressure it withstands all kinds of abuse.

"Far Superior to other types of rubber sheathed cables"

"WE have used it on all manner of jobs such as welding steel tanks, steamboat boilers, and various emergency jobs. I am pleased to say that today the cable is in perfect condition, and apparently good for some years to come.

"The braided cables which we formerly used are not to be compared with your special Super Service Welding Cable, and we also find this product far superior to other types of rubber sheathed cables which we have used."

This statement is taken from a letter from Mr. Ray Gaul, president of the Albany Welding, Boiler and Machine Shop, after his Super Service Welding Cable had been in use for three years.

You can't beat Super Service for wear, and its extreme flexibility eliminates the need for splicing on a separate length of wire for the electrode holder.

If you have never used Super Service get a length today and try it out.

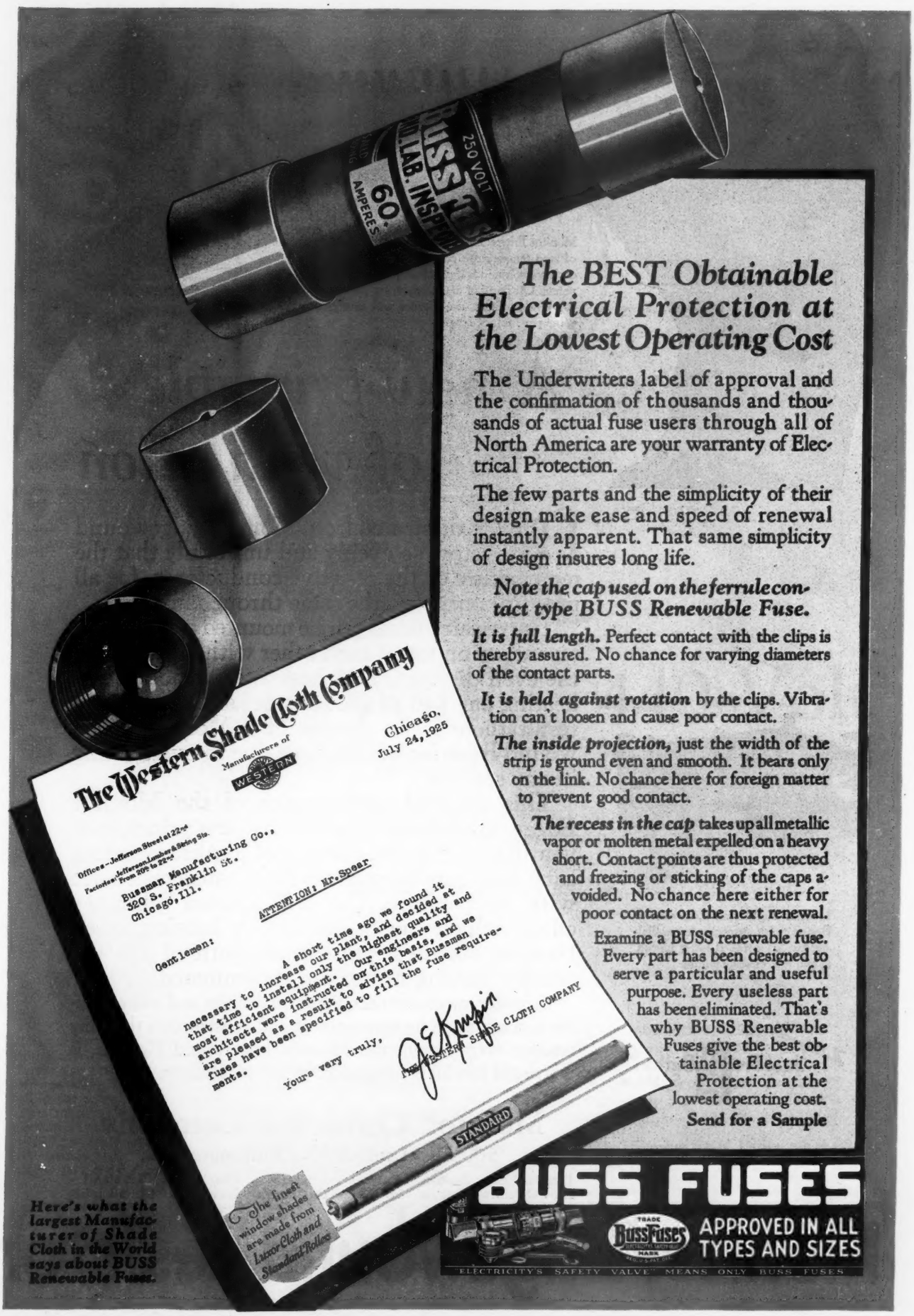
ROME WIRE COMPANY
Mills and Executive Offices: Rome, N. Y.
Diamond Branch: Buffalo, N. Y.

New York—50 Church Street *Boston*—Little Building *Chicago*—14 E. Jackson Blvd.
Detroit—25 Parsons Street *Cleveland*—1200 West 9th Street
Los Angeles—J. G. Pomeroy, Inc., 336 Azusa Street
San Francisco—J. G. Pomeroy, Inc., 51 Federal Street

SUPER SERVICE
CORDS *and* CABLES

2542

A ROME WIRE PRODUCT


250 VOLT
60 AMPERES
The Western Shade Cloth Company
Manufacturers of
WESTERN
Chicago,
July 24,1925
Offices--Jefferson Street at 22nd
Factories--Jefferson,Loomis & Throop Sts.
From 20th to 22nd
Busman Manufacturing Co.,
320 S. Franklin St.
Chicago,Ill.
ATTENTION: Mr.Spear
Gentlemen:
A short time ago we found it necessary to increase our plant, and decided at that time to install only the highest quality and most efficient equipment. Our engineers and we architects were instructed on this basis, and we are pleased as a result to advise that Busman fuses have been specified to fill the fuse requirements.
Yours very truly,
THE WESTERN SHADE CLOTH COMPANY
STANDARD
The finest window shades are made from Lustor Cloth and Standard Rollers

Here's what the largest Manufacturer of Shade Cloth in the World says about BUSS Renewable Fuses.

The BEST Obtainable Electrical Protection at the Lowest Operating Cost

The Underwriters label of approval and the confirmation of thousands and thousands of actual fuse users through all of North America are your warranty of Electrical Protection.

The few parts and the simplicity of their design make ease and speed of renewal instantly apparent. That same simplicity of design insures long life.

Note the cap used on the ferrule contact type BUSS Renewable Fuse.

It is full length. Perfect contact with the clips is thereby assured. No chance for varying diameters of the contact parts.

It is held against rotation by the clips. Vibration can't loosen and cause poor contact.

The inside projection, just the width of the strip is ground even and smooth. It bears only on the link. No chance here for foreign matter to prevent good contact.

The recess in the cap takes up all metallic vapor or molten metal expelled on a heavy short. Contact points are thus protected and freezing or sticking of the caps avoided. No chance here either for poor contact on the next renewal.

Examine a BUSS renewable fuse. Every part has been designed to serve a particular and useful purpose. Every useless part has been eliminated. That's why BUSS Renewable Fuses give the best obtainable Electrical Protection at the lowest operating cost.

Send for a Sample

BUSS FUSES

TRADE BussFuses MARK

APPROVED IN ALL TYPES AND SIZES

"ELECTRICITY'S SAFETY VALVE" MEANS ONLY BUSS FUSES

Monitor Edgewound Resistors are made of ribbon of zero temperature coefficient of resistivity and each convolution is individually supported at two points. On basis of air temperature permitted by the Underwriters, these units will dissipate 60 watts per inch of length.

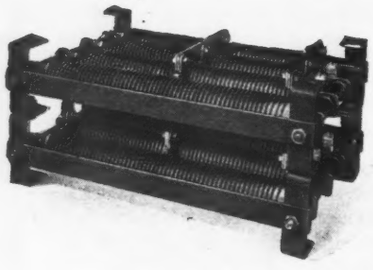
A new principle of ventilation

HEAT is dissipated from Monitor Edgewound Resistors so evenly and uniformly that the temperature of the resistive conductor is, for all practical purposes, the same throughout.

The resistor units can be mounted side by side, on end, or on top of each other without affecting the even dissipation of heat and without overheating any part of the resistor as a whole. As a result there is no danger of a Monitor Edgewound Resistor burning out due to overheating in any section.

This unusual performance of the Monitor Edgewound Resistor is due to a new principle of ventilation plus the absence of localized heating such as occurs in resistors that change resistance with temperature. The well known "chimney effect" which causes cumulative heating, often burning out those parts in the path of the upwardly moving heated air, is eliminated.

Stronger, more compact, lighter in weight and more flexible and simple in its arrangement and construction than any resistor ever known, the Monitor Edgewound Resistor, is worthy of careful investigation. Write for Bulletin 107.



Monitor Eight-unit Edgewound Resistor with four units in parallel and two in series. Resistor tapped at two intermediate points.

The Original "Just Press Button" System

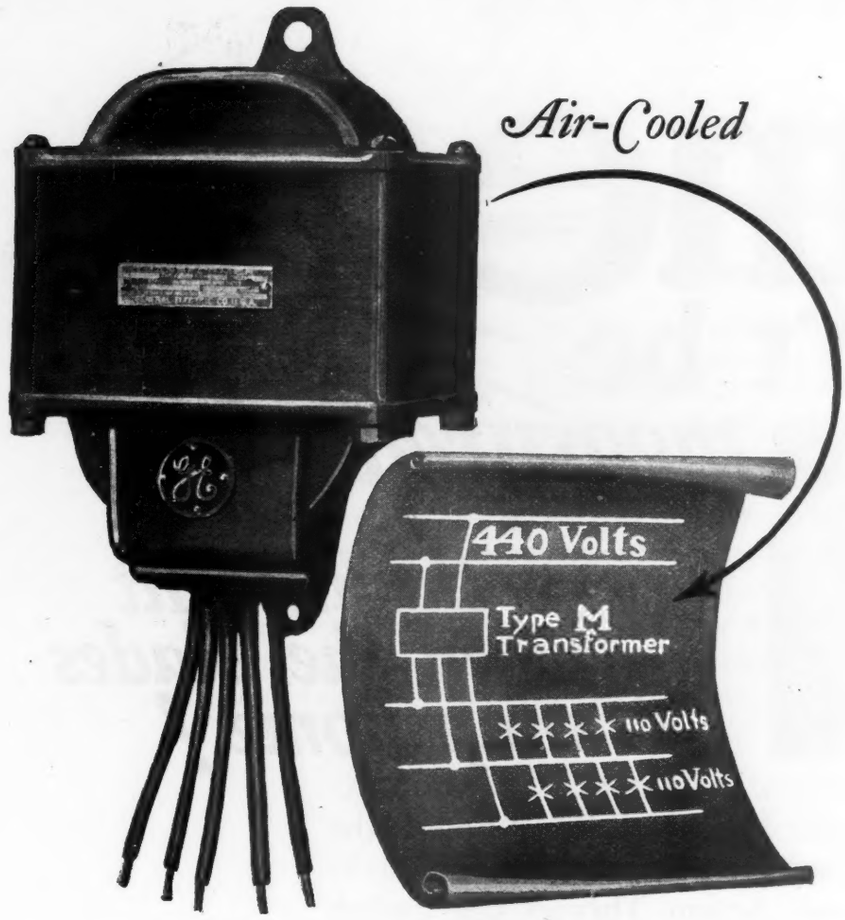
Monitor Controller Company

500 East Lombard St., Baltimore, Md.

Birmingham Boston Buffalo Chicago Cincinnati Cleveland
New Orleans Detroit St. Louis Pittsburgh New York Philadelphia

6720-2

Monitor Edgewound Resistor



110-Volt standard lamps *on* 440-Volt power circuits

Nominal 110-volt circuits can be obtained from 220-volt, 440-volt, or 550-volt sources of supply by installing a Type M Transformer. This enables the use of standard lamps and equipment without putting in a special circuit.

Sizes of these transformers are 15 to 5000 watts, 60 cycles, and up to 3000 watts, 25 cycles, all 600 volts and below.

The outstanding characteristic of Type M Transformers is that they are *air-cooled,* utilizing no oil in their construction. This makes them ideal for indoor use. Bulletin 65105 gives all details as to ratings and dimensions. Ask for a copy.

Type M Transformers are admirably adapted to many other low-voltage needs including 3-phase to 2-phase transformations.

They are ideal for *special* low-voltage requirements as well, because "specials" can readily be built from standardized "M" parts.

They are attractive in appearance, and their construction is such that they may be mounted indoors or outdoors as desired. They can also be furnished for conduit wiring installations.

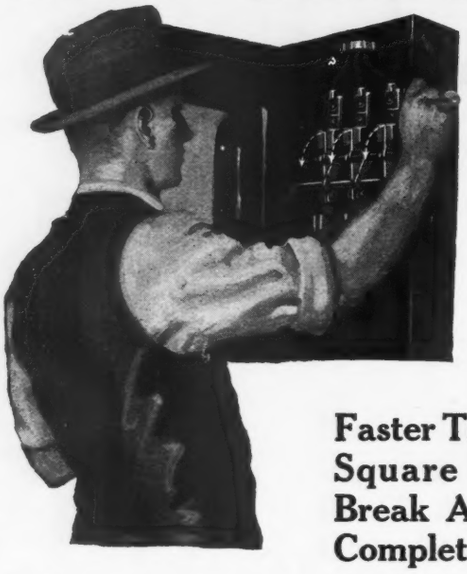
Tell the nearest G-E Office what you wish to accomplish.

17F-2

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL LARGE CITIES

Time that can't be measured!



.... the instant when the blades snap home!

Faster Than the Eye can Follow, the Square D Quick-Make, Quick-Break Action Throws the Switch Completely *On* or Completely *Off*.

In Square D you have the advantage of the simplest and most efficient design to accomplish positive quick make and break. Square D blades snap solidly home with clean, instant, perfect contact at all points—and disengage just as quickly. The switch is *on* or *off* with a minimum of arcing.

Added to this important feature there are many other outstanding Square D advantages—individual base construction that makes part replacements quick and simple; key controlled accessibility and safety; dust proof and dirt proof enclosure for long life and trouble-free service.

Such efficiency, such sturdiness, such quality, have built Square D's unquestioned leadership—leadership based on three million successful installations.

We invite your personal inspection of Square D. Ask your jobber or write us direct.

SQUARE D COMPANY, DETROIT, U.S.A.
FACTORIES AT: DETROIT, MICH., PERU, IND. (71)
BRANCH OFFICES: Boston, Buffalo, Chicago, New York, Pittsburgh, St Louis, Philadelphia, Cincinnati, Milwaukee, Atlanta, Cleveland, San Francisco, Los Angeles, Syracuse, Kansas City, New Orleans, Baltimore, Columbus, Minneapolis, Indianapolis.
SQUARE D COMPANY, CANADA, LTD., WALKERVILLE, ONT
BRANCH OFFICES: Toronto, Montreal

SQUARE D
Safety Switch

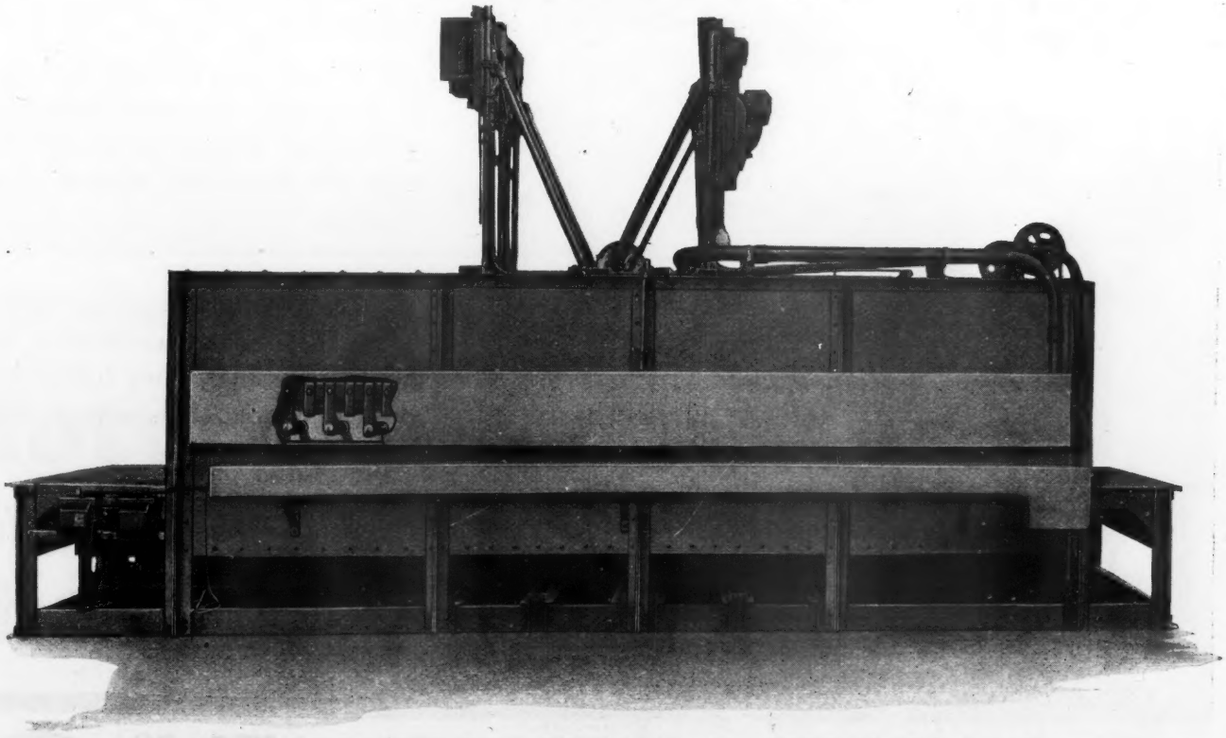
Globar

NON METALLIC **ELECTRIC HEATING ELEMENT** CARTRIDGE TYPE

Globar Heating Elements are particularly adaptable for Industrial applications by virtue of their high operating temperatures. They operate successfully at any temperature up to 2750 degrees F, (1500 degrees C). Globar Elements are increasing efficiency in production — effect a new economy — permit of accurate temperature control and solve element mounting troubles. Let our Engineering and Development Laboratory help you with your present furnace problems.

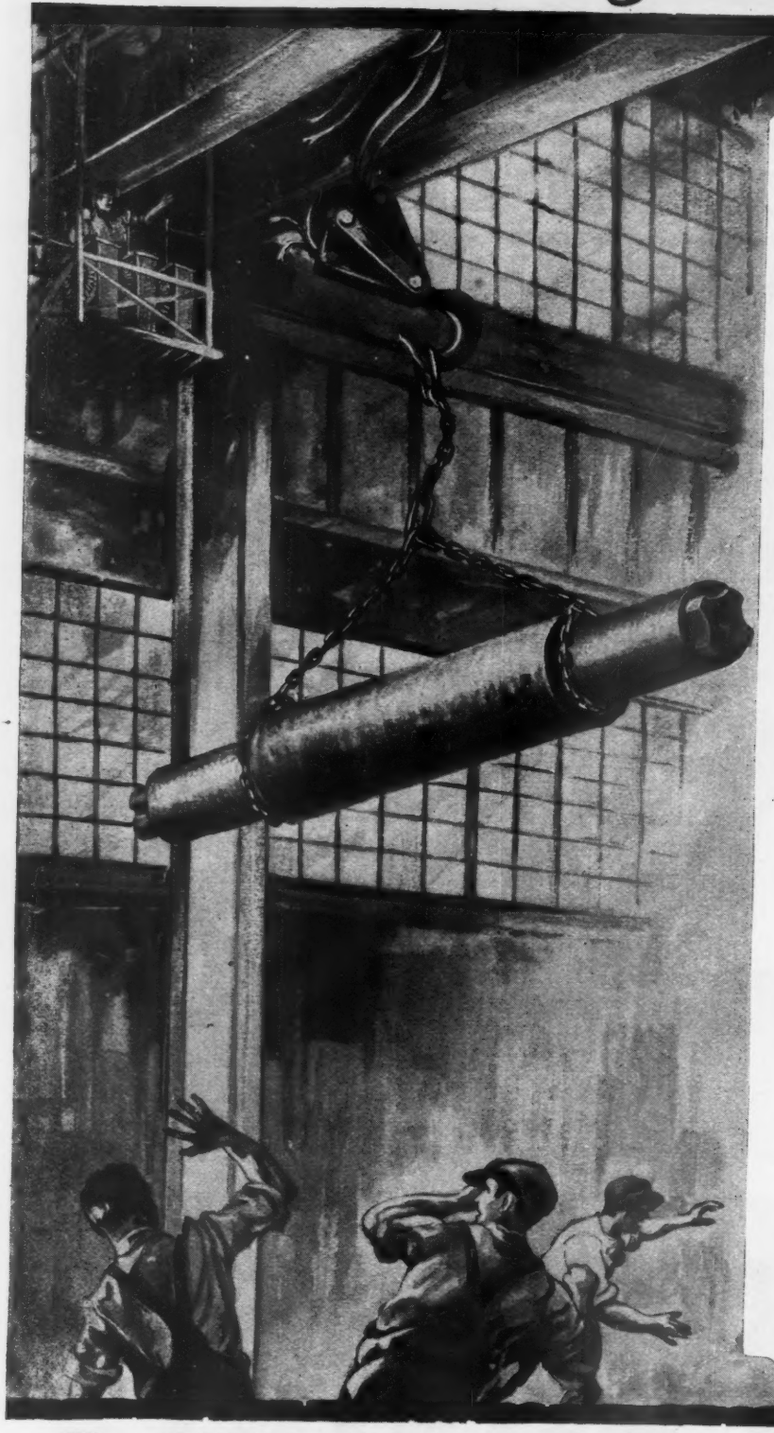
American Resistor Company
Milwaukee

New York—Philadelphia—San Francisco—Los Angeles



THE ELEMENT OF ECONOMY

—and no Youngstown Limit Stop



A moment of carelessness—the operator fails to realize that the hook is too high—unnoticed, it travels beyond the point of safety—**AND NO YOUNGSTOWN LIMIT STOP—**

The operator throws his controller to reverse—but too late—too late for the safety of the men on the floor below—hoisting ropes snap—the heavy bottom block and load drop—

Had you ever thought that such an accident can easily happen in your plant if your cranes are not properly protected against over-hoisting?

EC&M Youngstown Safety Limit Stops make accidents of this kind impossible. They have never been known to fail in their operation.

Send for Bulletin 1040-B

THE ELECTRIC CONTROLLER & MFG. CO.

BIRMINGHAM-BROWN-MARX BLDG.
CHICAGO-CONWAY BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
DETROIT-DIME BANK BLDG.
NEW YORK-50 CHURCH ST.
CLEVELAND, OHIO
LOS ANGELES-THOMAS MACHINERY CO. AMERICAN BANK BLDG.
PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
SEATTLE-570 COLMAN BLDG.
TORONTO-TRADERS BANK BLDG.

Motors Built for the Job

DESIGNED by the Louis Allis Company, a motor becomes an integral part of the machine to which it is applied. Electrically and mechanically right, it assures the consistent efficiency of any equipment. That is why you will find L-A motors so frequently "built-in."

An engineering department, skilled in meeting difficult requirements, and a production department in giving unusual service, are at your command.

THE LOUIS ALLIS CO.

Milwaukee, Wisconsin.

Immediate Service on Louis Allis Motors!

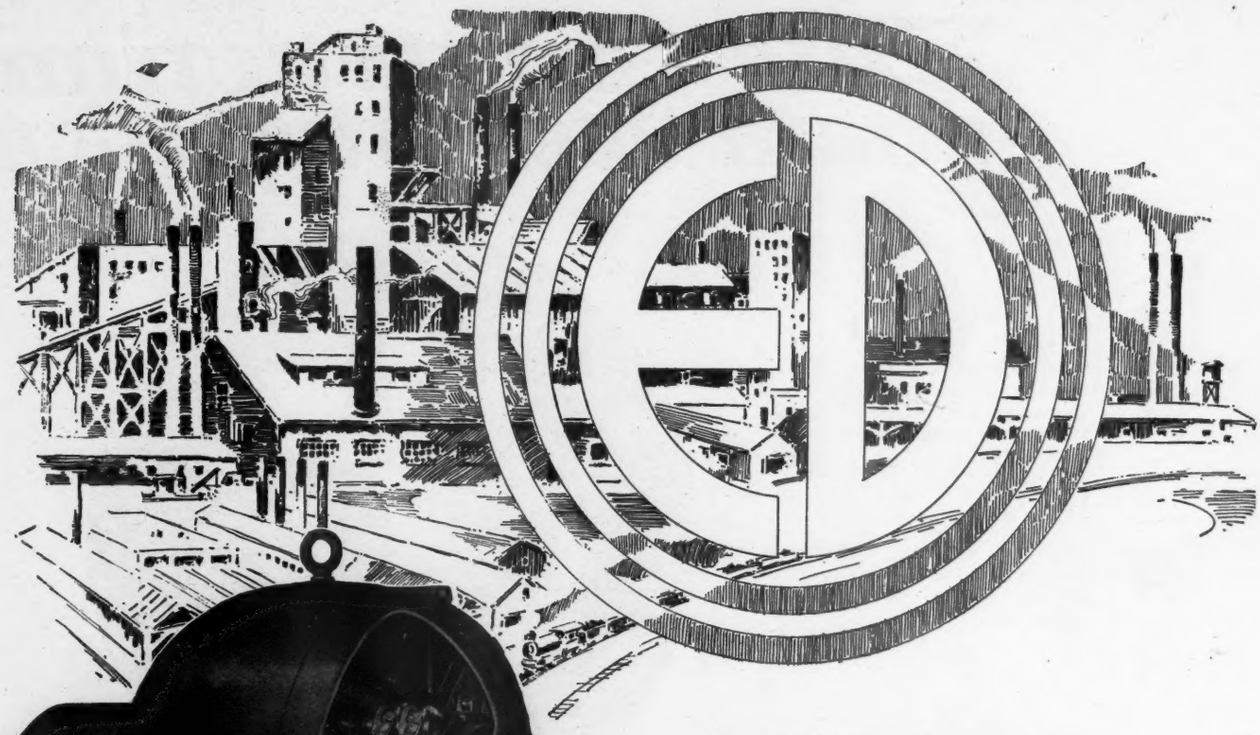
The red dots—each representing a Louis Allis sales office or service connection—tell the story.

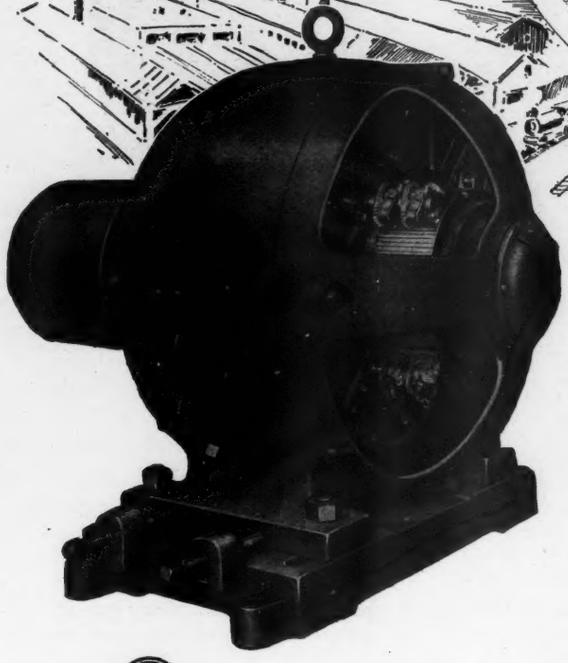
Manufacturers, whose machines are L-A motored, are assured of prompt service at any point in the United States. A service for our customers—and their customers.

THE LOUIS ALLIS COMPANY, Milwaukee, Wisconsin

DISTRICT OFFICES AND REPRESENTATIVES

BOSTON	514 Atlantic Avenue
BUFFALO	607 White Building
CHICAGO	332 South Michigan Avenue
CINCINNATI	720 Providence Bank Building
DETROIT	2539 Woodward Avenue
GRAND RAPIDS	41-43 Elsworth Avenue
MILWAUKEE	133 Stewart Street
MINNEAPOLIS	927 Metropolitan Life Building
NEW YORK	8 East 41st Street
PHILADELPHIA	2401 Chestnut Street
PITTSBURGH	1213 Bessemer Building
ST. LOUIS	410 Granite Building
TORONTO, CANADA	350 Bay Street
VANCOUVER, CANADA	London Building
WINNIPEG, CANADA	68 Higgins Avenue





The first ball bearing motor

-Electro Dynamic Motors-

All industry reflects E.D. performance

Everywhere in industry you can find Electro Dynamic Motors cutting power costs. For they maintain a day-in-and-day-out service that reduces to a minimum time and money spent on repair and maintenance. Years of hard service have proved their ability to stand the gaff of constant usage.

But such performance can be traced back to E.D. design. For E.D. was the pioneer ball bearing motor and it has maintained such progressiveness of design at all times. So that today it stands in the forefront of motor lines for all industry.

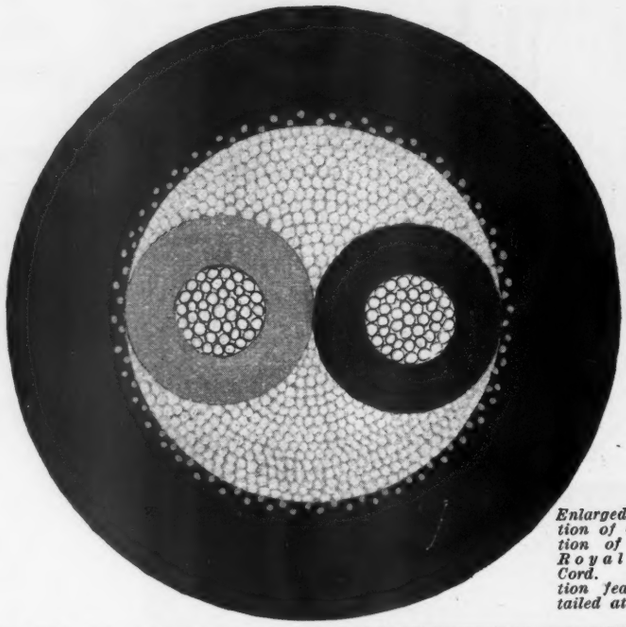
Whatever your motor problems may be, our Engineering Department will gladly work with you in selecting a standard type or suggesting a special type of E.D. Motor to fulfill your requirements.

Send for our bulletins to get further particulars

ELECTRO DYNAMIC CO.
BAYONNE, N. J.

This construction -guarantees satisfaction

1. The conductors are made up of very fine strands of highest quality copper wire, accurately drawn to size.
2. They are insulated, over a cotton wind, with a wall of 30% rubber. The polarity is indicated by different colored compounds.
3. The conductors are twisted together with a strong filler of long staple cotton.
4. Conductors and filler are encased in a network of heavy silk finish thread.
5. The outer cover is a jacket of special "U. S." Royal Cord compound of the highest grade gum rubber, uniform in diameter, and forced into form under pressure in specially designed machines.



Enlarged reproduction of cross section of "U. S." Royal Portable Cord. Construction features detailed at the left.

Tough Flexible Waterproof

Trade US Mark

"U. S." Royal Portable Cord will stand up under an unparalleled amount of punishment. The construction features shown in the above cross section indicate the story behind "U. S." Royal's dependability.

"U. S." Royal Portable Cord is built to give longer service under even the most severe industrial conditions. The rubber cover is compounded to resist the attack of corrosive elements and extreme abrasion. The interior construction of Royal Cord insures against any possible injury from pulls, jerks, twisting and turning and provides for extreme flexibility.

Years of experience in research and development work and a thorough knowledge of working conditions by the United States Rubber Company have developed this unequalled Portable Cord. The experience of thousands of users has taught them to always specify "U. S." Royal Portable Cord. They have learned that there is no other cord that assures them such long and uninterrupted service from their portable electric equipment.

Send for a Sample to Test for Yourself

United States Rubber Company

1790 Broadway, New York City

Complete Stocks Carried in the Following Cities:

Atlanta	Columbus	New Orleans	Salt Lake City
Baltimore	Denver	New York	San Francisco
Birmingham	Detroit	Omaha	Seattle
Boston	Houston	Philadelphia	Spokane
Buffalo	Indianapolis	Pittsburgh	St. Louis
Chicago	Kansas City	Portland, Ore.	Syracuse
Cincinnati	Minneapolis	Rochester	Toledo
Cleveland			

"U.S." Royal Portable Cord

Poor light puts production to sleep—*Good lighting wakes it up*

The well-lighted factory is the pace-maker in its field—and enjoys costs appreciably lower than do competitors. This has been proved by engineers and works managers in every branch of industry.

Yet four of every five plants are poorly lighted—have lighting that makes production costs excessive.

Good artificial lighting in your plant will give a 15% increase in production or its equivalent in lowered manufacturing costs.

To learn if your plant is properly lighted, get in touch with your local electric service company, electric league or club. Without any obligation to you, they will study your lighting needs and recommend improvements that will effect economies in your plant.

Remember: 200 watt lamps with proper reflecting equipment spaced ten feet apart give excellent lighting.

INDUSTRIAL LIGHTING COMMITTEE
NATIONAL ELECTRIC LIGHT ASSOCIATION
29 WEST 39TH STREET
NEW YORK

Good Illumination

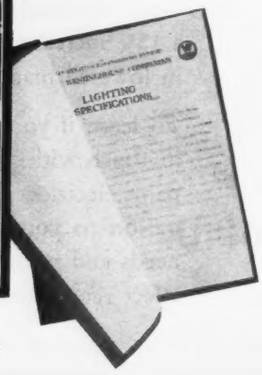
Greater Accuracy Reduces Spoilage

(Talk No. 3)

RECORDS made in hundreds of factories that have put in correct illumination show an average decrease of 25 per cent in spoilage. This decrease is due, largely, to the greater accuracy of workmanship that is possible under correct lighting conditions.

Did you ever try to read a micrometer by the light of a candle? It is practically impossible to do so accurately, and yet in many factories the actual light intensity is no greater where the mechanic must take his reading.

Plenty of illumination is equally necessary in any factory where man-



An Illumination Survey

Without cost and without obligation, the Westinghouse Illuminating Engineering Bureau will make a complete survey of your plant. It will then make an unbiased recommendation, telling the present condition of your illumination and how your lighting system could be changed to give an illumination that will pay dividends.

Westinghouse

X85525

Pays Dividends

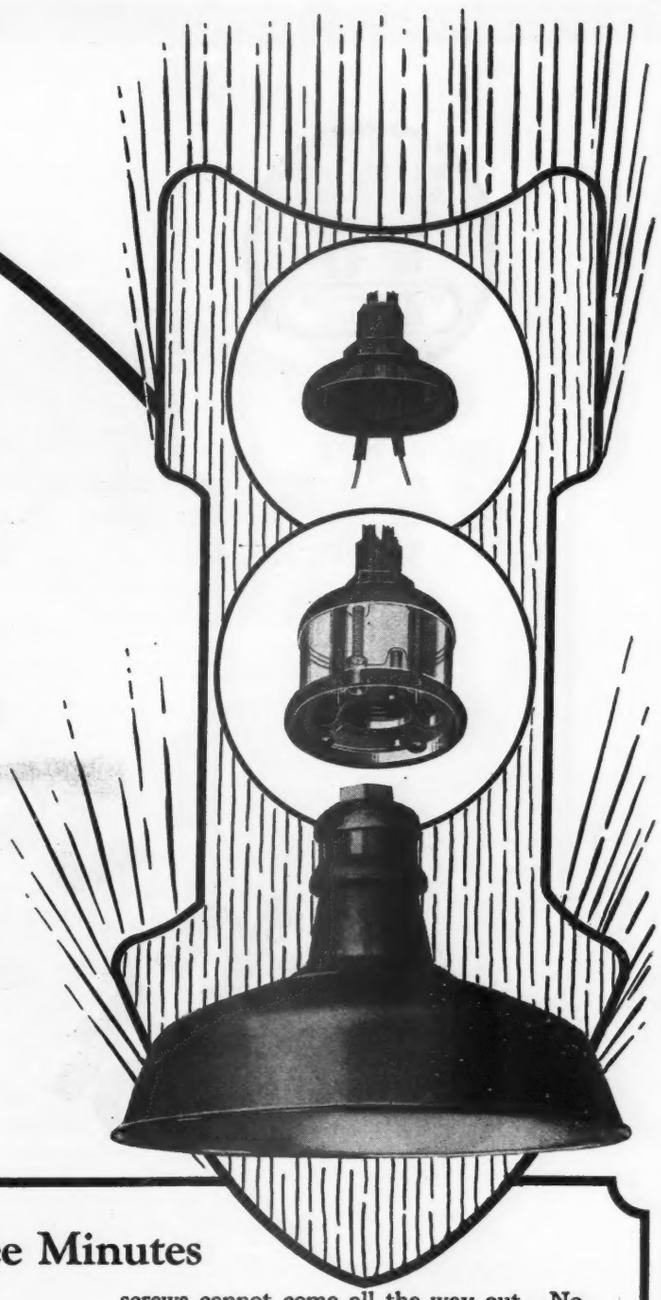
ufacturing operations require close vision.

Lighting conditions other than low intensity may cause spoilage. Glare, shadows, and light from improper directions all cause eye-strain and discomfort. Inaccuracy, with the consequent spoilage, is sure to follow.

All these facts show the necessity for expert knowledge in problems of industrial illumination. Our Illuminating Engineering Bureau places such knowledge at your disposal.

It may be that our Bureau could show you a way to reduce ***your*** spoilage. The advice will cost you nothing and will obligate you in no way.

Westinghouse Electric & Manufacturing Company
Merchandising Department South Bend, Indiana
Sales Offices in All Principal Cities of
the United States and Foreign Countries



Completely Wired in Three Minutes

The Reflector-Socket-Fixture has but three parts. A speed test will prove beyond question its "Easy-to-Wire" claim. Any electrician can completely wire and install the fixture in three minutes.

But three simple operations are necessary.

(1) The cast iron cap is screwed directly onto the conduit.

(2) The wires are drawn through holes in the one-piece porcelain socket. The socket is fastened to the cap with two screws. These screws cannot come all the way out. No loose screws are present to cause fumbling. The operation is completed by clamping the wires under contact screws.

(3) The Reflector is fastened to the socket by three screws. Bayonet slots in the reflector's heel reduce the operation to a slight twist of the reflector and a few turns of the screws.

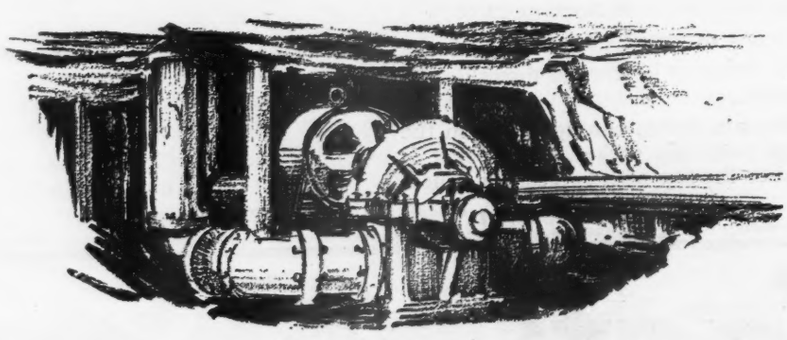
Reflector-Socket-Fixtures are rigid, weather-proof, and extremely serviceable.

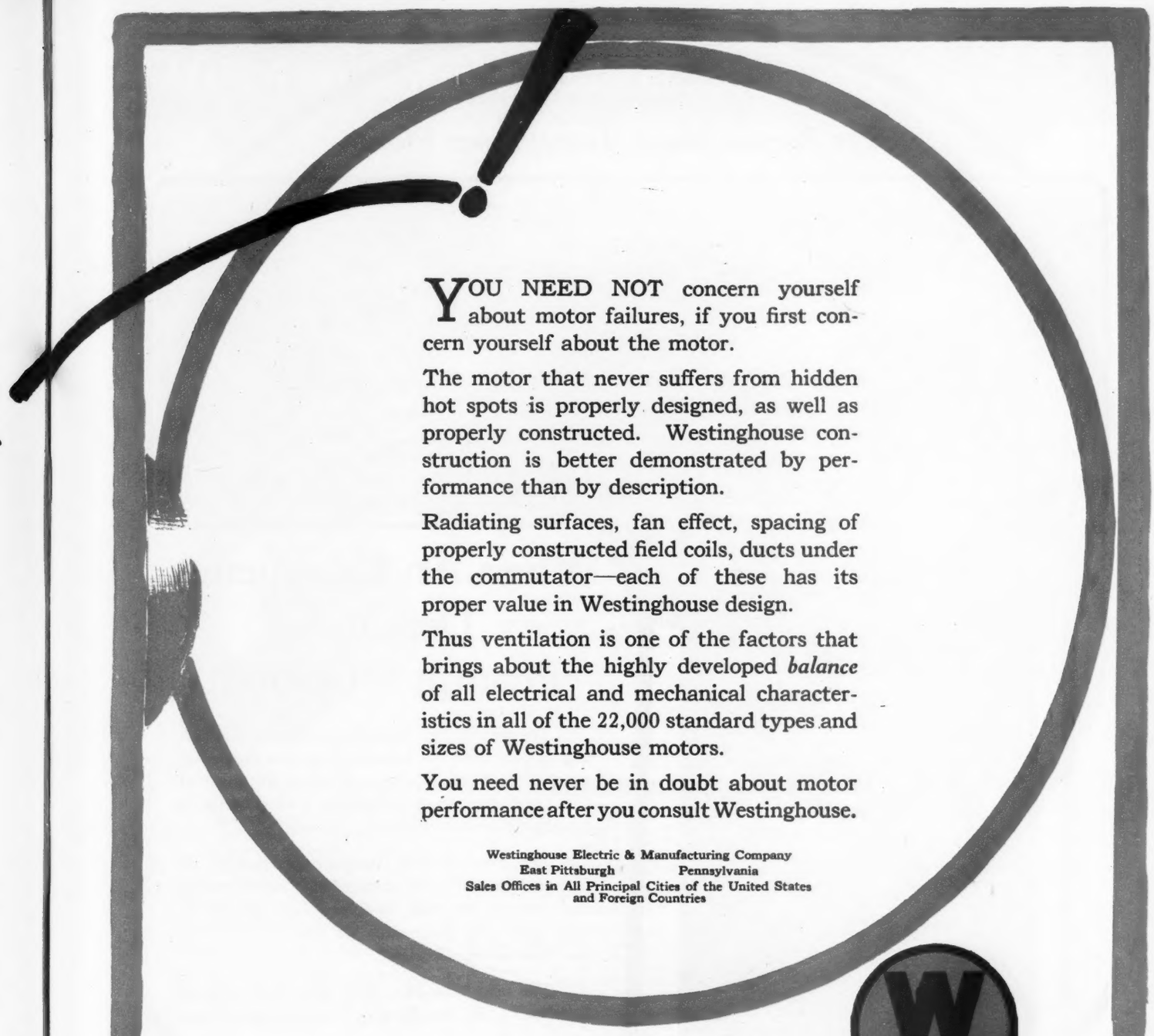
Holder-Socket Reflectors are "Easy to Wire"

Westinghouse

X85986

W
WESTINGHOUSE
ELECTRIC
Cash value
of ventilation





YOU NEED NOT concern yourself about motor failures, if you first concern yourself about the motor.

The motor that never suffers from hidden hot spots is properly designed, as well as properly constructed. Westinghouse construction is better demonstrated by performance than by description.

Radiating surfaces, fan effect, spacing of properly constructed field coils, ducts under the commutator—each of these has its proper value in Westinghouse design.

Thus ventilation is one of the factors that brings about the highly developed *balance* of all electrical and mechanical characteristics in all of the 22,000 standard types and sizes of Westinghouse motors.

You need never be in doubt about motor performance after you consult Westinghouse.

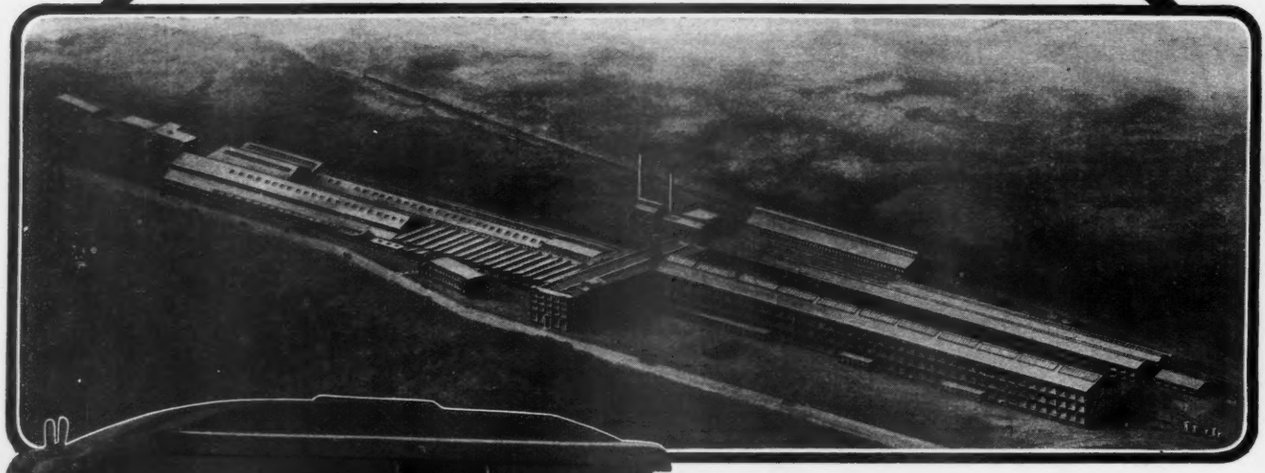
Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

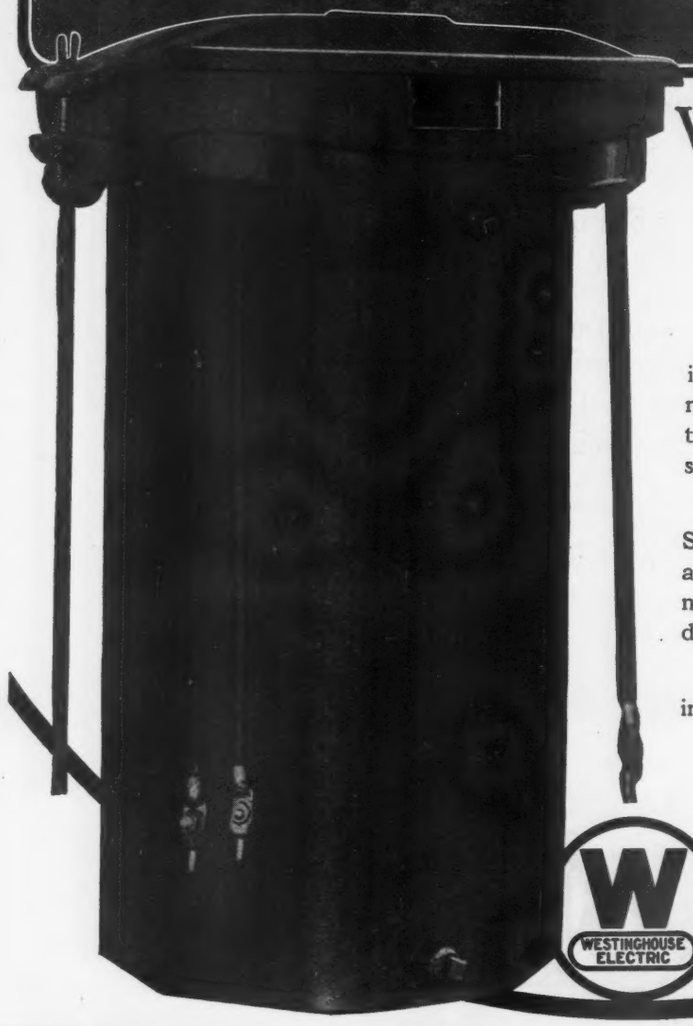
W
WESTINGHOUSE ELECTRIC

Westinghouse Motors *are balanced!*

SHARON WORKS
Sharon, Pa.

The Westinghouse Transformer Plant





When An Emergency Demands Prompt Shipment

The distribution transformer is the connecting link between the power station and the equipment using electric power. Prompt shipment of these transformers is frequently a vital factor in supplying service for new equipment.

The new 42-acre transformer factory at Sharon, Pa., with its unexcelled manufacturing and testing facilities, enables Westinghouse to meet promptly these calls for rush shipment of distribution transformers.

The next time you need some transformers in a hurry, let our Sharon Works supply them.

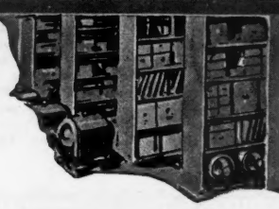
Westinghouse Electric & Manufacturing Company
Sharon Works Sharon, Pa.
Sales Offices in All Principal Cities of
the United States and Foreign Countries

W
WESTINGHOUSE ELECTRIC

Westinghouse

X 85519

MAINTENANCE SERVICE, REPAIR PARTS, TOOLS AND SUPPLIES



In the maintenance departments of every industrial works and in every commercial electrical repair shop the range of the work that can be done and the dollar-savings that are possible depend on
(1) The ability and experience of the maintenance man.
(2) Adequate hand and bench tools and shop equipment.
(3) A well-balanced stock of spare units, parts, wiring supplies and raw material used in repair work.

Here then is a directory to the needs of the maintenance man under items (2) and (3) that he can use when he must have things in a hurry on an emergency job and when ordering for stock to meet his regular maintenance requirements.

FIGURE IT OUT

Flower Brush Holders are designed and built by brush holder specialists to meet the needs of a specific job. They're simple — they're rugged—and they're made only from the finest virgin metals. Naturally they last longer, are more reliable, and practically eliminate "flashover" risks.

Quotations gladly given on any type.

FLOWER
BRUSH HOLDERS

D. B. FLOWER
1217 Spring Garden Street, Philadelphia

Manufacturers of Brush Holders for Motors, Rotary Converters, Generators and Dynamos

"JIFFY" CUTTER

cuts clean round holes quickly and easily, thru steel boxes and switchboard panels.

Saves time and money on every job.

Adjustable Diameters ¾ in. to 6 in. Weighs only 3½ pounds.

Write today for a copy of
"THE HOLE STORY"
It tells the whole story

PAUL W. KOCH & COMPANY
23 So. Wells St., CHICAGO

Miller

Composition Mallets

"Much pleased with its durability."

"Your composition mallet has been in use two weeks steadily. One week it was used on No. 14 galvanized, another week on No. 24 Black Iron. Mechanics are very much pleased with its durability. It is still going strong."

(From an unsolicited testimonial)

Users usually get fifteen times the service as with an ordinary wood mallet.

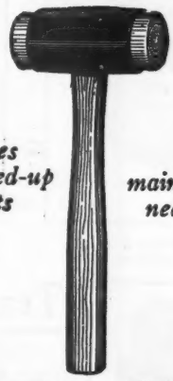
Write for Prices

The Miller Rubber Co.
of N. Y.
Akron Ohio

A Hard Blow Without Injury!

"Chicago Rawhide"

Mallets & Rawhide-faced Hammers



Saves battered-up parts

A maintenance necessity

Will transmit an effective blow without damage to the most delicate surface.

But the blow is not more destructive to the tool itself than to the object to which it is applied—therefore, doubly economical.

The Products of our manufacture include:

Belting—Lace Leather—Belt Lacing

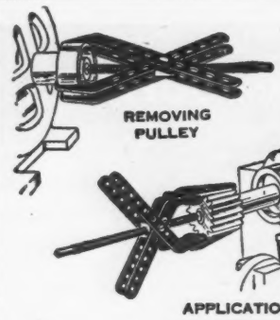
Hydraulic Cups and Packing—Mabb's Rawhide Packing — Rawhide Gears — Leather Straps — Washers — Gaskets — Leather Specialties for all purposes

The Chicago Rawhide Mfg. Co.
1279 Elston Ave. Chicago, Ill., U. S. A.

At Your Service—

A service wherein the man who is seeking a position or the man who is desirous of obtaining trained men; where information can be found concerning either the purchase or disposal of used equipment. The purpose of the *SEARCHLIGHT* section of *Industrial Engineer* is to render this service. It simply remains for industrial men to apply this service to their needs.

For Every Business Want—Think *Searchlight* First



–a few turns and OFF!

Any pulling job, in any plant or repair shop, is a matter of minutes if LITTLE GIANT or BIG BUSTER is at hand. Small pulleys, gears, flywheels, bearings, etc.—anything up to thirteen inches—will come off for LITTLE GIANT. For heavier work, such as truck wheels or big drive and flywheels, BIG BUSTER will do the trick. LITTLE GIANT and BIG BUSTER are the only pullers operating on the patented principle—"The Harder the Pull the Tighter the Grip"—arms cannot spread and slip off work. Adjustable to varying lengths for uneven pulls—an exclusive feature. Reversible for inside as well as outside pulls.

Price—Little Giant $12.00—Big Buster $50.00.
WRITE FOR ILLUSTRATED FOLDER describing more fully these remarkable tools and the work they do.

Premier Electric Company
1808 Grace Street, Chicago

OHIO ARMORED WEATHERPROOF CONNECTOR

Connect or disconnect instantly (no tools or tape required). Think of the time saved in connecting magnets, welding machines, etc. Made single pole as illustrated, also double or three-pole.

THE OHIO ELECTRIC & CONTROLLER CO.
5910 MAURICE AVENUE CLEVELAND, OHIO

"CARENCO" BRUSHES

Can't be surpassed for service and efficiency on any type of motor or generator. After a *thorough test*, many of the biggest users have adopted "Carenco" Brushes as *standard equipment.*
Let us send you our new catalog and data sheet. Prove the value of "Carenco" Brushes to yourself!

CARBON-ENGINEERING-CO.
MILWAUKEE, WIS.

Have You Enjoyed Reading This Copy?

For $2.00 a Year You Can Get One Like it Every Month

Use the coupon at the bottom of page 90

Copper Wire all kinds
Insulating Varnishes
Super-Safety Switches
Electro-Nite Carbons
Commutator Truing Device
Mica Undercutting Tools

ARTHUR B. WEEKS
419 High Ave. Cleveland, Ohio

NO Spark Carbon Brushes

are Self Lubricating. They last longer and serve better than ordinary Brushes. Give them just one trial.

Calebaugh Self-Lubricating Carbon Co.
1503 Columbia Ave.
Philadelphia, Pa.

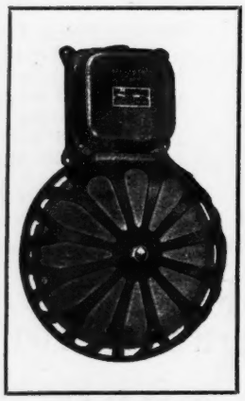
Weatherproof SCHWARZE Vibrating Bells

With Manual Trip Attachment

No. 6c D. C. Cyclone
No. 7c A. C. Cyclone

Nos. 76 and 77
A. C. Cyclone Bell

No. 6 D. C. Cyclone
No. 7 A. C. Cyclone

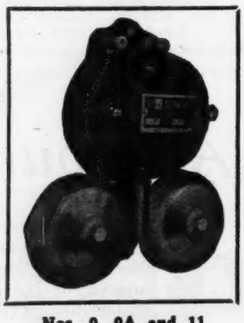


Full Protective Grid

No. 75
A. C. Cyclone

Transformer and High Voltage A. C.
Battery and High Voltage D. C.

Cyclone bells are approved by National Board of Fire Underwriters for Industrial Signalling. They are the most reliable bells for Fire Alarm and General Calls in your plant. Write factory or nearest branch office for catalogue and full particulars.

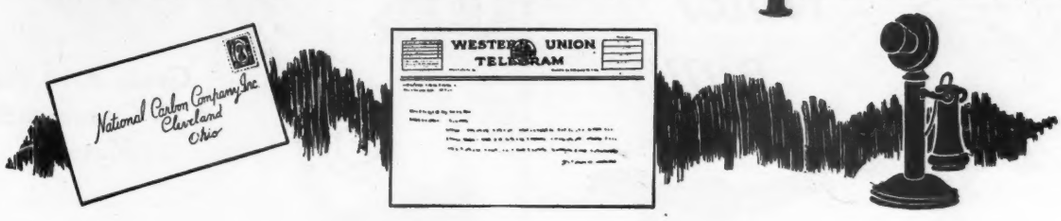


Nos. 9, 9A and 11
A. C. Polarized

Branch Offices:
Minneapolis, Minn. 915 Metropolitan Life Bldg.
San Francisco 515 Market St.
Detroit, Mich. 1444 Park Place E.
New York City 291 Broadway
Los Angeles 212 Calo Bldg.
Chicago, Ill. 627 W. Jackson Blvd.
Philadelphia, Pa. 481 Bourse Bldg.
Seattle, Wash. 222 Hinckley Bldg.
Cleveland, Ohio 452 Leader-News Bldg.
Boston, Mass. 132 Pearl St.
St. Louis, Mo. 1415 Pine St.

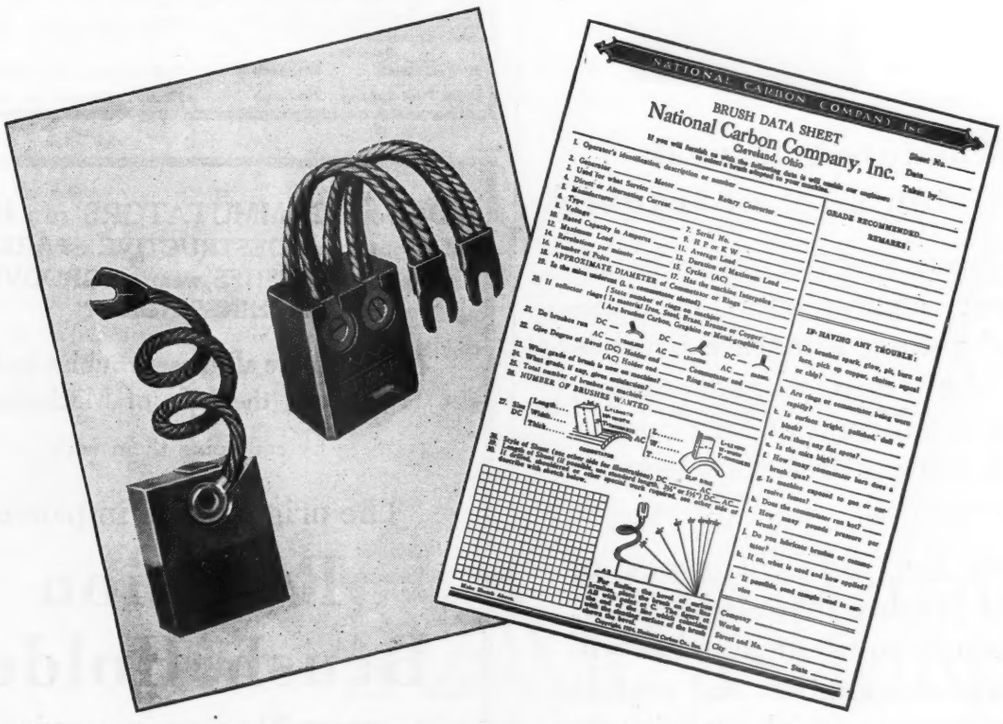
Main Office and Factory
Schwarze Electric Co., Adrian, Mich., U. S. A.

write – wire – phone



WHEN you need brushes on short notice for any reason *write, wire* or *phone* the nearest of our four plants, and the National Pyramid Brushes you need will be on their way to you immediately.

Have we complete data sheets on your motors, generators and converters? Information regarding our data sheet service gladly sent on request.



The services of our Sales Engineers are always at your disposal

Manufactured and guaranteed by

NATIONAL CARBON COMPANY, INC.

Carbon Sales Division

Cleveland, Ohio San Francisco, Cal.

Canadian National Carbon Co., Limited, Toronto, Ontario

Emergency Service Plants

CHICAGO, ILL.
551 West Monroe St.
Phone: STAte 6092

PITTSBURGH, PA.
Arrott Power Bldg. No. 3
Barker Place
Phone: ATLantic 3570

NEW YORK, N. Y.
357 West 36th St.
Phone: LACkawanna 8153

"Your armature brush can start or stop a lot of trouble"

It's a question of the proper brush for your requirements — a question of getting armature brushes with the right abrasiveness, proper co-efficient of friction and correct contact drop for your particular motors.

Among the different types of H & H brushes there is one to fit your exact requirements, that will assure cool operation and perfect commutation with minimum wear.

Let us go into your particular requirements with you.

HOHMAN & HILL, Inc.

1900 Southport Ave., Chicago, Ill.

Grade R-14 For A.C. Commutating Motors

A well known New England textile mill uses a number of A.C. commutating motors in their spinning room. They formerly kept an electrician in that room all the time but since using Corliss R-14 brushes they have not spent an hour on brush trouble.

CORLISS CARBON CO.
BRADFORD PA.

District Offices
90 West Street New York
Union Trust Building Pittsburgh

Distributors
Beckett Electric Co., Dallas, Monterrey
Electrical Specialty Co., San Francisco

Do your **COMMUTATORS run HOT?**
Do you have **DESTRUCTIVE SPARKING?**
Are your **BRUSHES wearing GROOVES?**
Are your **MACHINES NOISY?**

Eliminate all these troubles and Prolong the Life of Machines

by equipping them with

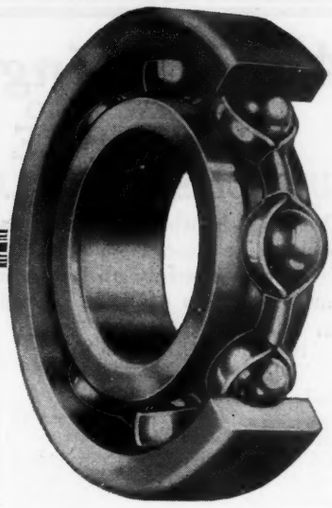
The original and improved

Reaction Brush Holder

over 20 years in service

Let us equip a Generator or Motor for ***you.*** Make its ***final acceptance*** subject to your ***approval after any reasonable period of operation.***

THE BAYLIS CO.
50 Nelson Street
BLOOMFIELD, N. J.



Advantages of ball bearings for electric motors

THIS advertisement is the twelfth of a series appearing monthly in this magazine. Previous advertisements have summarized the following advantages of ball bearings for electric motors:

1. *Short overall length of motor*
2. *No shorts from oily windings*
3. *Clean bearings*
4. *Small, constant air gap*
5. *Reduced maintenance costs*
6. *Thrust load capacity*
7. *Repair bills cut*
8. *Smaller stock of spares*
9. *Belted in any position from any direction*
10. *International interchangeability.*
11. *Long life*

XII. Higher Efficiency

Motor friction losses cost money,— power money. And anything that reduces such losses means a real dollars and cents saving in the owner's pocket.

Here is where ball bearing motors show a decided advantage over motors of any other type.

Assume, for example, that a ball bearing motor is only 2% more efficient than a sleeve bearing motor of the same rated capacity,— and this figure is conservative, according to available comparative performance data. Then 30 motors, each delivering 10 H.P. and running 3000 hours a year, would show an annual saving of 30x10x3000x.02=18,000 H.P. hours. At a cost of 2c a horsepower hour this would amount to a yearly saving in power of $360 for the 30 motors.

Note that this is a saving in power only. It does not include the corresponding savings in lubrication, maintenance, and production losses already considered in previous advertisements of this series.

THE FAFNIR BEARING COMPANY

Makers of high grade ball bearings, the most complete line of types and sizes in America

NEW BRITAIN, CONN.

Chicago Newark Cleveland Detroit

FAFNIR
BALL BEARINGS

THE MOST COMPLETE LINE OF TYPES AND SIZES IN AMERICA

Look into these Continuous-tooth Herringbone IXL Gears

They Have Some BIG Advantages

IXL Herringbone Gears and Speed Reducers are especially adapted for heavy duty drives, high speeds, continuous service, where high efficiency is an important factor and where vibration and noise are objectionable.

Advantages of Continuous Generated Teeth with 30 Degree Helix Angle

1. Greater load carrying capacity.
2. Greater strength of tooth.
3. Greater Bearing surface per tooth.
4. No undercutting of teeth.
5. Extreme quietness of action.
6. Narrower faced gears to transmit same HP.
7. Elimination of Backlash.
8. Minimum vibration.

We make single, double and triple speed reduction units. Capacities up to 150 HP. and Reduction ratios up to 350-to 1.

We Manufacture
Cut Gears of all Kinds
Micarta Pinions
Micarta Timing Gears
Flexible Couplings
Gear Racks
Speed Reducers
Special Machinery

FOOTE BROS. GEAR & MACHINE CO.
236-246 N. Curtis St. Chicago, Ill.
Sales offices in all principal cities in U. S. and Canada.

FOOTE BROS. GEAR & MACHINE CO.
236-246 North Curtis Street
Chicago, Illinois

Established 1905

Please send us full information on IXL Herringbone Gears or Speed Reducers to meet our requirements as per the enclosed specifications. R-128

*Address*_____

*Signed*_____

Announcing—
THE NEW TRICO
GIANT SIZE
FUSE PULLER and REPLACER

The big brother to the standard pocket-size model—a rugged, oversize tool for safely and conveniently handling fuses of large capacity.

For fuses from
100-600 Amps. 250 V.
60-400 Amps. 600 V.

Made with 7 laminations of highest grade genuine horn fibre, tested at 35,000 Volts. A Brute for Size and Strength —just the thing for large installations.

WRITE TODAY for literature and name of nearest dealer.
NOTE: Ask for information on Trico Powder Packed Time Limit Renewable Fuses — "Famous for Their Performance" —the line that reduces blowouts 80 per cent.

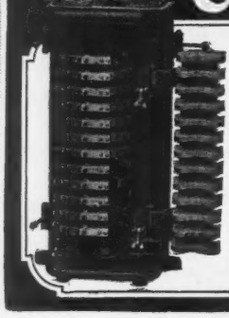
Trico Fuse Mfg. Co.
Dept. A
Milwaukee, Wis., U. S. A.

TRICO REG. U. S. PAT. OFF.

GIANT SIZE Length 12 in. Price $3.00 In U. S. A.

POCKET SIZE Length 7½ in. Price $1.00 In U. S. A.

UNION Controllers



Specially designed for
Hoisting Machinery.
Metal and Woodworking equipment.
Electric Trucks and Tractors.
Mine Locomotives.
Pumps, Fans and Blowers.
All General-Purpose Motor Control applications.

Send for bulletins and detailed information.

Union Electric Mfg. Co.
Milwaukee, Wis.
20 *Sales and Service Offices*

TRANSFORMERS
That's Us!

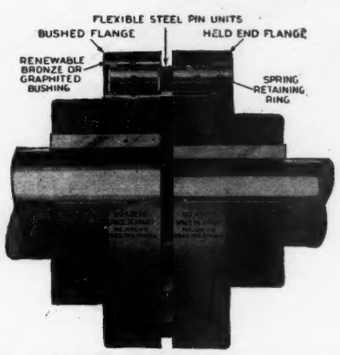
LARGE OR SMALL. When you are in the market for transformers, get our quotations. *Any voltage—any capacity.* We are in position to give prompt deliveries on quality built transformers.

Campbell Mfg. Company
19 Stewart Street Lynn, Mass.

The New, Improved *Effective Dec. 1, 1925*

FRANCKE
FLEXIBLE COUPLINGS

For Motor, Turbine, Engine Drives



Bushed Pin Type

Graphited bronze bushings in Size No. 850 and larger (bronze bushings in smaller sizes) are removably locked in one flange. The steel pin units are free to slide a full half inch within these bushings. Contact surfaces are more than doubled; a cylindrical surface is obtained; movement is between steel and bronze; and the graphited bushings present a self-lubricated surface that retains its lubricating qualities for many years.

The Improved Francke Coupling retains the best features of the old Heavy Pattern Type and adds several new features to make a better coupling. More and easier endwise movement. Greater power and bore capacities Much longer life for all speeds. Steel flanges for small and intermediate sizes. **Lower prices.**

The Francke handles all accidental misalignments—Out of center, in an angular direction and endwise; cushions starting and load shocks; absorbs vibrations; runs in either direction; is noiseless.

In case of excessive misalignment it acts as a safety device saving broken or scored shafts, bearing troubles, etc. However, if more than the usual misalignments are expected, due to non-rigid foundations or for any other reason, two couplings in tandem with an intermediate shaft or a Double, Floating-Ring Type Francke Coupling should be used.

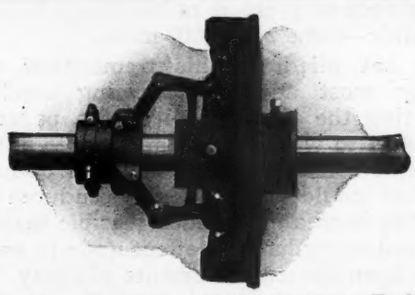
Other Francke Features. Easily mounted, aligned and connected without special tools. All metal, no perishable material. No movement or wear on shaft flanges to cause expensive renewal of complete coupling. Simple and safe.

Ask for Bulletin 37S

SMITH & SERRELL
Coupling Specialists Since 1912

26 Washington Place, Newark, N. J.

WELLER
STEEL PLATE
FRICTION CLUTCHES



NOTE the Absence of Projecting Bolts or Lugs
Also Compact, Solid, General Lines.

WELLER MADE CHICAGO

We make
a Complete Line of
Transmission Machinery
For Belt or Rope Drives
also
Conveying Machinery
Send for Catalogue 35A Transmission Machinery

WELLER MFG. CO.
1820-1856 N. Kostner Avenue **CHICAGO, ILL.**

SALES OFFICES

New York	Buffalo	Baltimore	Pittsburgh
Detroit	St. Louis	Omaha	Salt Lake City

SPEED REDUCING UNITS

Up to 5 H. P. Capacity

Send for Catalog

WINFIELD H. SMITH
116 Eaton Street **Springville, N. Y.**

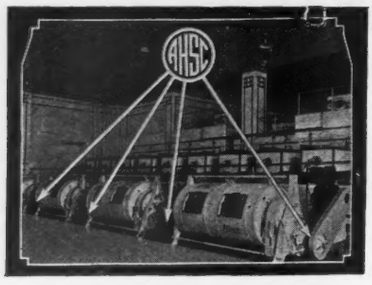
Torrington BEARINGS

Accurate
Dependable
Quiet
Samples or Specifications on request

The Torrington Company
ESTABLISHED 1866
TORRINGTON, CONN., U.S.A.

Simplicity Plus 98% to 99% Efficiency

American High Speed Chains operating churns in Fox River Creamery Co., Chicago.



Efficiency At Its Highest

No device is more efficient than American High Speed Chain. It is the "ball bearing" of power transmission. It is 98% to 99% efficient.

Your plant needs American High Speed Chain Drives just as machines of high efficiency need ball bearings. They save power, avoid practically all the costly break-downs experienced with other forms of power transmission, and speed up production.

We now have a complete stock of chains and sprockets up to 10 H. P. and 7 to 1 reduction, from which we can ship on less than 48 hours notice. Ask for Catalog No. 105.

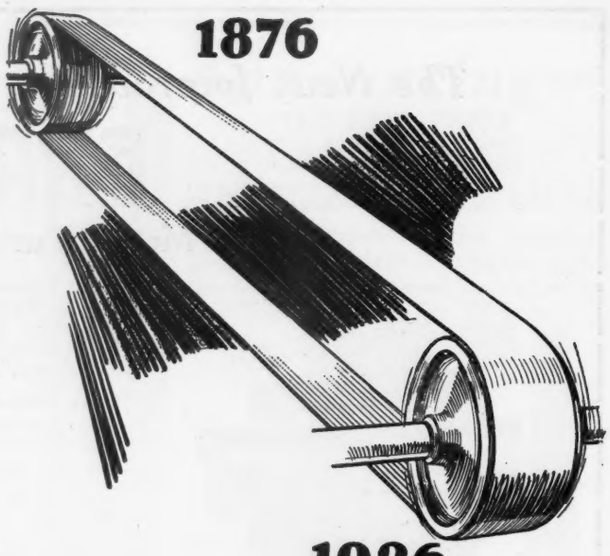
If you desire conclusive proof, try American High Speed Chains on some of the drives in your factory. They will sell themselves to you and soon you will have your whole plant equipped with them. Save power!

Write for Our Catalog

AMERICAN
HIGH SPEED CHAIN CO.
Indianapolis, Ind.
NEW YORK, 50 Church St.
CHICAGO, Monadnock Block
AHSC

Simplicity Plus 98% to 99% Efficiency

1876



1926

SEMICENTENNIAL OF A GREAT BELT

IN 1876 there were exhibited at the Centennial Exposition "—three monster leather belts—the largest 60 inches wide, 176 feet long, and weighing 1,130 pounds."

When General Grant opened the Exposition by starting the great Corliss Engine, this belt was first set in motion —*and it is in active service use today!*

For almost fifty years this "Centennial" belt has been running night and day, day in and day out, in a paper mill in Wilmington, Delaware. It has traveled around its pulleys a distance so great as to be almost incomprehensible—some 20,000,000 miles.

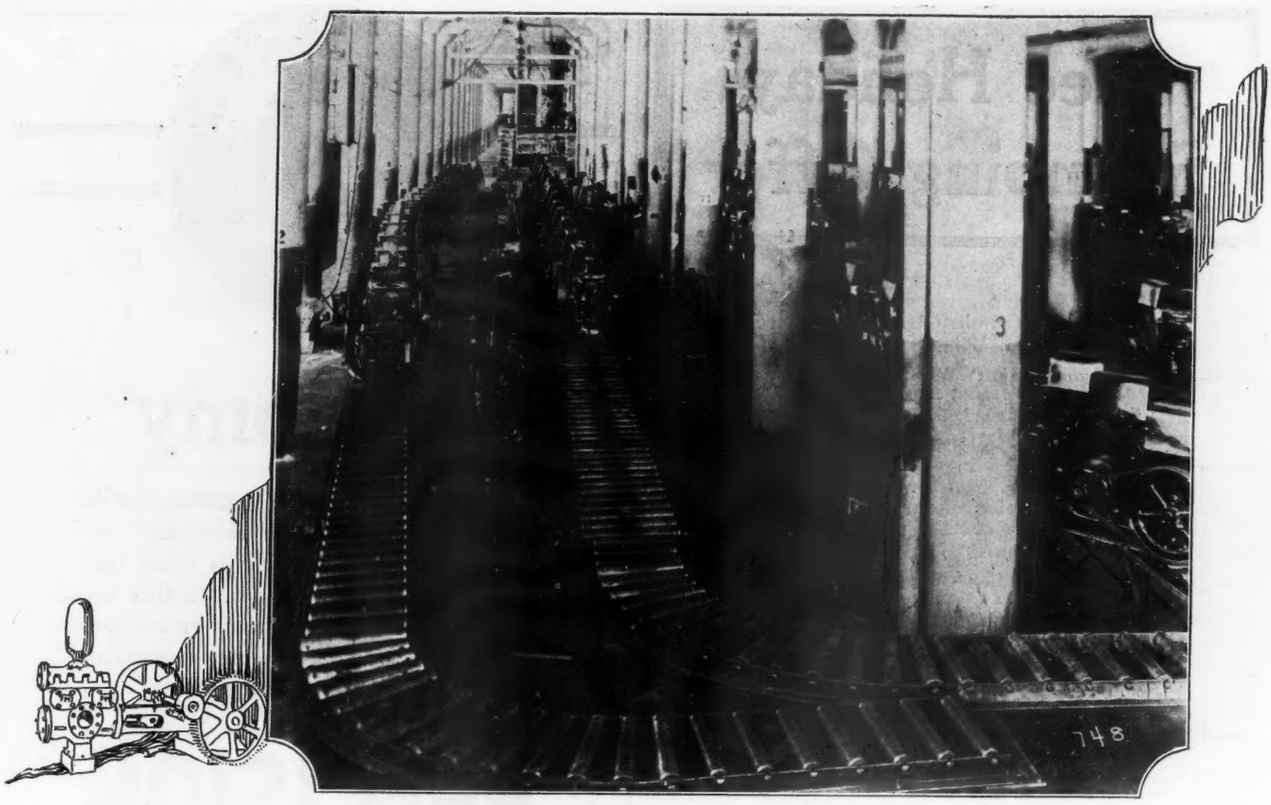
It has piled up this tremendous record under most adverse operating conditions. Meeting the heavy service of a paper mill, exposed to water and dampness, to extremes of heat and cold—what material other than leather could have possibly endured? For leather is an almost indestructible material—air and water have no effect upon it, and it is free from the usual elements of decay.

Beyond all question this famous old belt was one of excellent quality. But during the long years of its service there have been marked advances in the art of tanning, and it is quite certain that the first-quality leather belting on the market today is fully equal, if not superior, to the "Centennial" belt in quality, and capable of rendering equally remarkable service.

LEATHER BELTING EXCHANGE
417 Forrest Building Philadelphia, Pa.

Nothing takes the place of

LEATHER



What makes Standard Conveyors Economical?

That's the question Fairbanks-Morse and Company wanted to know before installing the Standard System. They know now, and are daily receiving additional evidence from their own conveyors.

Standard Gravity Conveyors bridge the gaps between the cars, the material yards, the various shop operations, the assembly and storage houses to the shipping room. They eliminate much labor, require no power for operation and but little maintenance.

How a Standard Conveying System could help you, how it could reduce your handling costs and speed up production is a problem our engineers will gladly help you in solving. To call them in places you under no obligation. In the meantime we suggest that you write for a copy of catalogue IE 12.

STANDARD
CONVEYOR COMPANY,
NORTH SAINT PAUL, MINN.

Free Holiday Stamping Offer

Until January 1, 1926, we will stamp your name, or a friend's name, in gold on the front cover of any McGraw-Hill Book. Orders for stamped books should be accompanied by proper remittance and, of course, stamped copies are not returnable.

Underhill—Coils and Magnet Wire
494 pages, 6 x 9, 197 illustrations, $4.00
A practical book on the principal classes of coils and the magnet wires from which they are constructed.

Underhill—Magnets
449 pages, 6 x 9, 467 illustrations, $4.00
A practical treatise on electromagnetic devices, their circuits and the specific forms and characteristics of electromagnets and permanent magnets used today.

Consoliver—Automotive Electricity
665 pages, 5½ x 8, 656 illustrations, $4.00
A new book on the construction, operation, characteristics and maintenance of automotive ignition, starting, lighting and storage battery equipment. The book presents information on practically all types and makes of automotive electrical and battery systems.

Annett and Roe—Connecting and Testing D-C Machines
237 pages, 6 x 9, 172 illustrations, $2.50
A practical presentation of the problems arising in the re-connecting of direct-current machinery for changes in speed and voltage, with methods of making tests for the locating of faults and directions for the making of repairs. Many diagrams and worked-out problems are included.

Dudley—Connecting Induction Motors
Second edition, revised and enlarged, 361 pages, 6 x 9, 289 illustrations, $3.00
A presentation of practical questions arising in winding and connecting alternating current motors. It includes 159 standard diagrams.

Del Mar—Electric Cables
208 pages, 6 x 9, 58 illustrations, $2.50
This book presents principles underlying the design, manufacture and use of electric cables of all important types for practically all purposes.

Schuhler—Electric Wiring
361 pages, 5 x 8, 305 illustrations, $2.50
The book covers the fundamentals of electric wiring thoroughly from the splicing and soldering of conductors to telephone wiring.

McGRAW-HILL
FREE EXAMINATION COUPON

McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York.

☐ Send me the books checked with name stamped in gold on front cover. I enclose proper remittance and understand that stamped books are not returnable.

.....
(Name to Be Stamped)
This offer expires on Jan. 1, 1926

☐ Send me the books checked for ten days' free examination. I agree to return the books, postpaid, in ten days or to remit for them then.

.....Underhill—Coils and Magnet Wire, $4.00.
.....Underhill—Magnets, $4.00
.....Consoliver—Automotive Electricity, $4.00.
.....Annett and Roe—Testing D-C Machines, $2.50.
.....Dudley—Connecting Induction Motors, $3.00.
.....Del Mar—Electric Cables, $2.50.
.....Schuhler—Electric Wiring, $2.50.

Signed.....
(Please Print)
Address.....
Official Position.....
Name of Company.....
(Books sent on approval to retail purchasers in U. S. and Canada only.)
I.E. 12-1-25

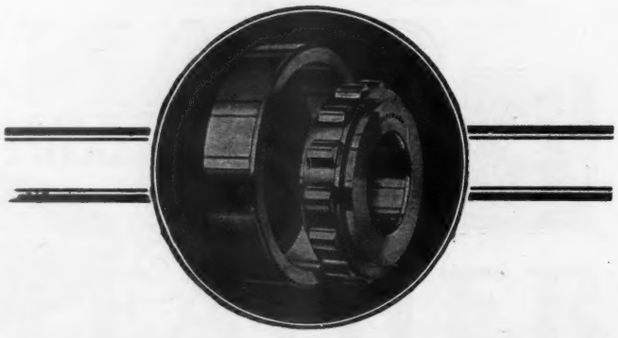
Economy

What a machine—or an improvement in a machine—costs, is of secondary importance. The big thing is what that machine will do, or how much that improvement will reduce costs or increase production. We've got to measure values by results—and by results only.

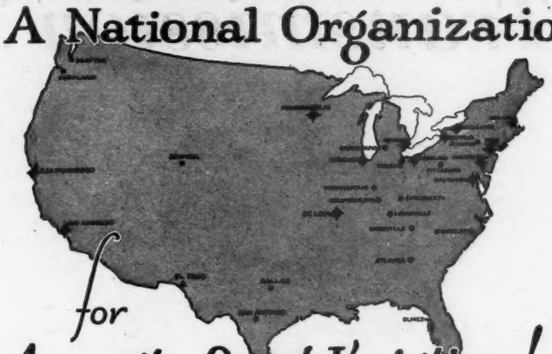
PRECISION BEARINGS

Incorporated in your machines will constitute a definite and tangible improvement—**"Norma"** Precision Ball Bearings where speeds are high and loads steady, **"Hoffmann"** Precision Roller Bearings for high speeds, heavy loads and shock or vibration. Our engineers have helped many a machine builder to add another factor to the economy of his product. Why not ask them?

NORMA-HOFFMANN BEARINGS CORPORATION
Stamford — Connecticut
PRECISION BALL, ROLLER AND THRUST BEARINGS



A National Organization



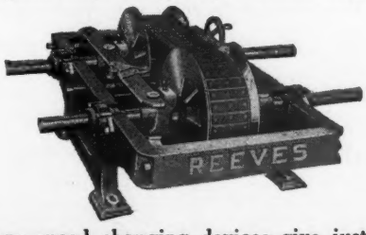
for

Accurate Speed Variation!

GET in touch with the REEVES representative nearest you and let him show you the advantages which accurate speed and variation will bring to the machines in your plant.

*Reeves-Bond Sales Company Chicago
*Reeves Pulley Company Detroit
Reeves Pulley Company Toledo
*Manning Maxwell & Moore New York & Boston
*Charles Bond Company Philadelphia
W. E. Shipley Mach. Co. Philadelphia
*Carey Mach. & Supply Co. Baltimore
*J. A. Webb Belting Co. Buffalo
*Strong, Carlisle & Hammond Cleveland
*Link Belt Meese & Gottfried San Francisco
*Link Belt Meese & Gottfried Los Angeles
Link Belt Meese & Gottfried Portland, Ore.
Link Belt Meese & Gottfried Seattle
*E. M. & W. Engineering Co. St. Louis
Neill-LaVielle Supply Co. Louisville, Ky.
F. Raniville Company Grand Rapids
Palmer-Bee Company Detroit
Charles B. Scott Company Scranton, Pa.
Ty-Sa-Man Machine Co. Knoxville, Tenn.
Charlotte Supply Company Charlotte, N. C.
Mine & Smelters Supply Co. El Paso
Skinner Machinery Company Dunedin, Fla.
T. L. Rose & Son Pittsburgh
Dodge Mfg. Corporation Cincinnati
Dodge Mfg. Corporation Atlanta
Dodge Mfg. Corporation Chicago
Wm. G. Kerr Pittsburgh
Vonnegut Machinery Company Indianapolis
M. L. Foss Denver
Martin & Campbell Company Detroit
*Cecil R. Lambert Company Detroit
*Cross Brothers Company Rochester, N. Y.
Alamo Iron Works San Antonio
J. E. Dilworth Company Memphis
*Chain Belt Company Minneapolis
Boston Gear Works Co. Chicago
Boston Gear Works Co. New York

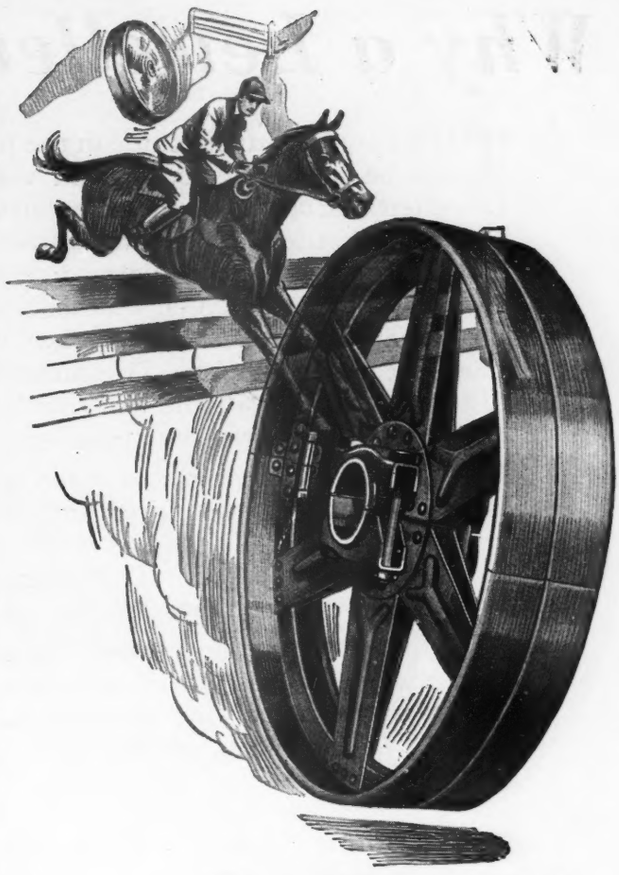
—indicates the representatives who carry a complete stock of REEVES Transmissions



Ordinary speed changing devices give just steps in speed, but steps are not exact enough for best results. Often, the speed you need is between the steps, and the REEVES Transmission is the only way of getting the "in-between" speeds accurately. You get literally millions of speeds with the REEVES—any speed between fastest and slowest, even to the smallest fraction of a revolution. Accurate and dependable, always.

REEVES PULLEY COMPANY
Established 1887
Columbus, Indiana

REEVES
Variable Speed Transmission



The HURDLES of HORSEPOWER

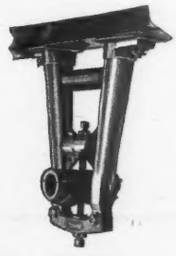
THE horsepower that leaves the boiler spends a part of its force in overcoming the obstacles encountered in every lap of its travel from the boiler to the last machine.

There is resistance and waste in the transmission of every form of energy—the Hurdles of Horsepower.

But because of the scientific design and construction of "American" Pulleys and "American" Hangers (both of steel) these hurdles are lowered and transmission losses are cut to a minimum.

There are sound reasons for this power saving. You will find them clear and understandable. Write for them.

Visit our exhibit, Booth 530, at Power Show, Grand Central Palace, New York, N. Y., November 30th to December 5th.



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The American Pulley Co.

Manufacturers of Steel Split Transmission Pulleys, Pressed Steel Shaft Hangers and Pressed Steel Shapes

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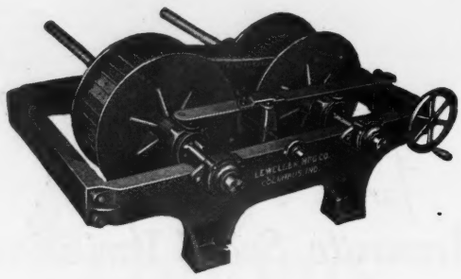
Why a Lewellen Transmission?

THE speed of any machine in the plant can be accurately controlled with a Lewellen variable speed transmission. It provides the best means known to modern practice for gradual and reliable variation of speeds. Old methods were unsatisfactory because they jerked from one speed to the next. The number of different speeds available was small. Accurate regulation was not possible.

With the Lewellen variable speed transmission, minute regulation and slight changes of speed—as well as wide variations—can be secured. The change is gradual, however—there are no jerks.

The Lewellen variable speed transmission makes it possible to control accurately the speed of any machine in the shop. Its use means distinct savings in production costs.

Lewellen Manufacturing Co.
Columbus, Ind.



The Lewellen complete ball bearing transmission is available from stock in sizes from 1 to 50 H. P. and in all speed ranges. It may be mounted on floor, wall, or ceiling. Equipped with hand, remote, or automatic control. The Lewellen ring oiling type of transmission, lower in price, is available for service where operating conditions do not warrant the complete ball bearing type.

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Midwest Steel Stringers, which are themselves quickly and readily installed in any type of building, provide in advance for changes of every kind in your overhead layout.

New equipment is quickly installed—old equipment can be moved to the exact point where it is needed—and even belting can be tightened without cutting and relacing of belts. Changes in the location of any overhead equipment are made without skilled labor, without time-consuming field work, or boring of holes. The only tool required is a bolt wrench.

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SEE how smoothly power is transmitted from the motor to this Ingersoll Rand Air Compressor by means of the efficient Link-Belt Silent Chain Drive.

This photograph, taken while the drive was running at high speed, clearly shows the action of the Silent Chain drive in transmitting power from the prime mover to the machine.

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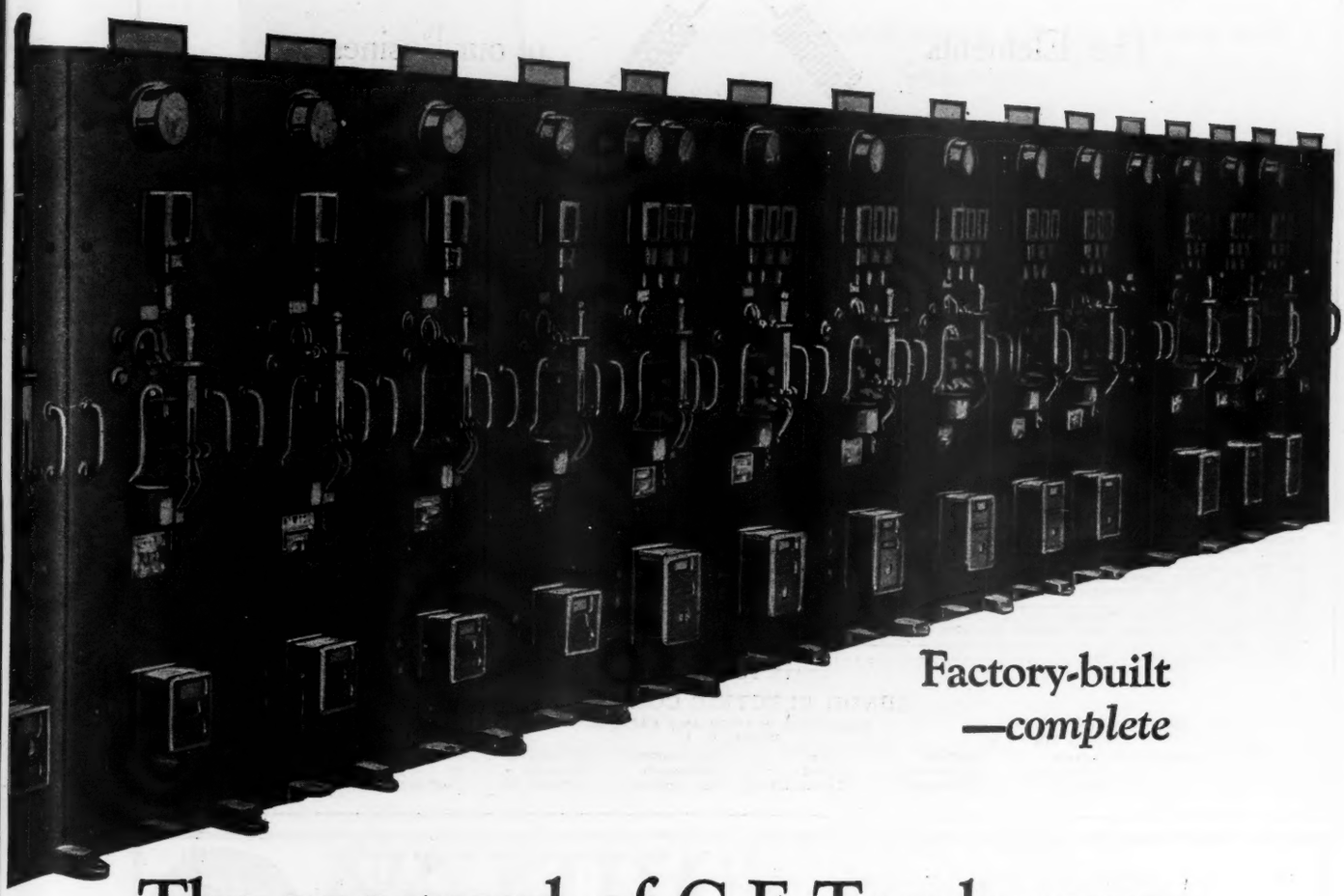

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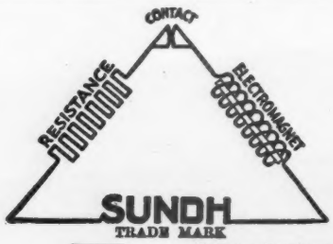

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Alarm, High and Low Liquid Level	3610-3615
Automatic Fire Pump Panels, Combined Hand and (See Panels, Fire Pump).	
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Brakes, Magnetic	9920
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Panels, Special	5400-5423
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Regulator, Pressure (See Pressure Regulator).	
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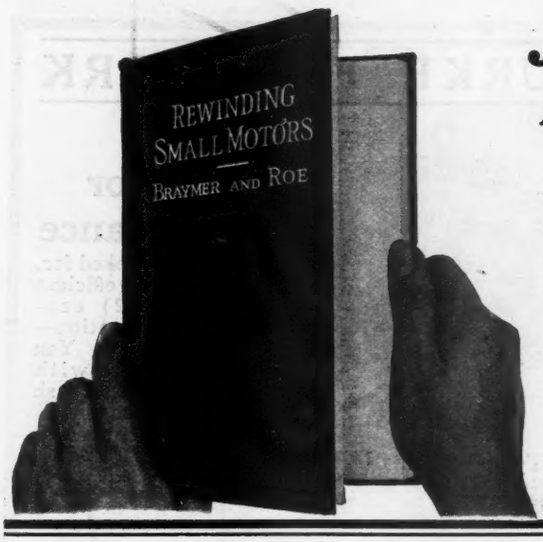

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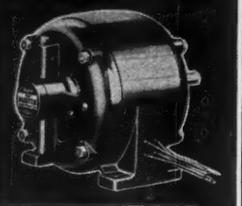

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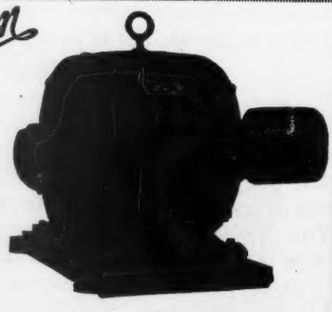

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At full load.

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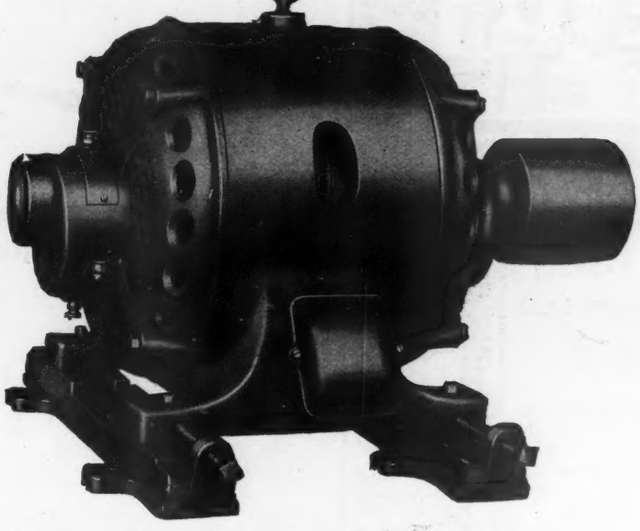

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Start Against Heavy Loads

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Built in all standard sizes from ½ to 60 horse power. Temperature rise not more than 40° Centigrade.

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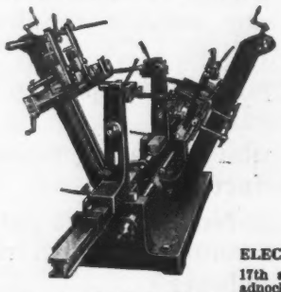

Showing Coil in Position

Improvements have been made in the coil blocks, the end-supporting knuckles and in the accuracy with which the machine duplicates the angular relation of the slot portion of the coil. The machine embodies the latest ideas in coil-forming equipment, and the setting-up time has been materially reduced.

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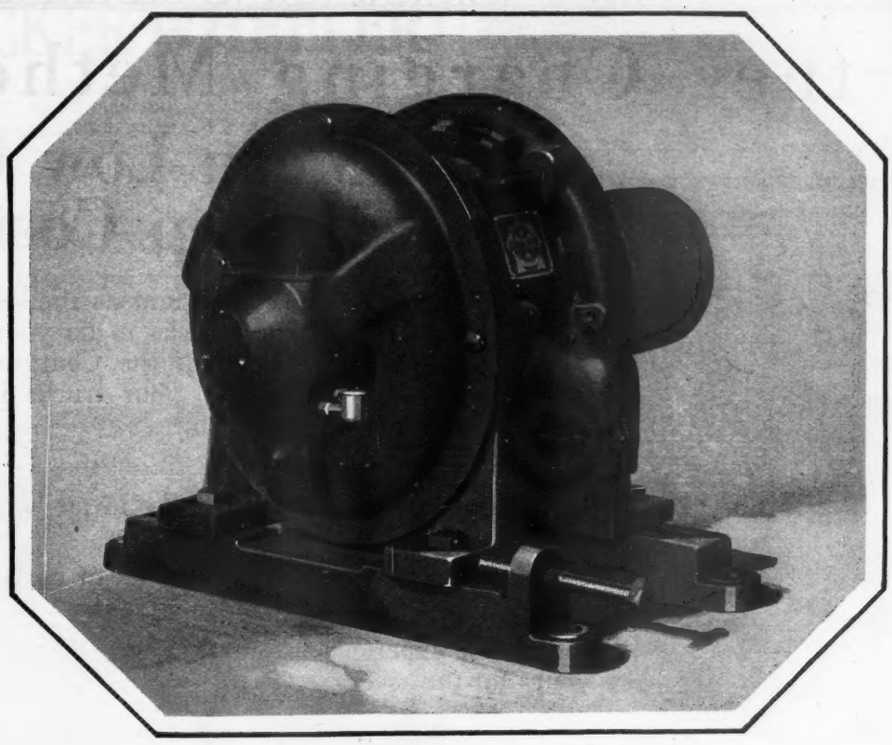

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are made with—

ball bearings
or roller bearings
or sleeve bearings

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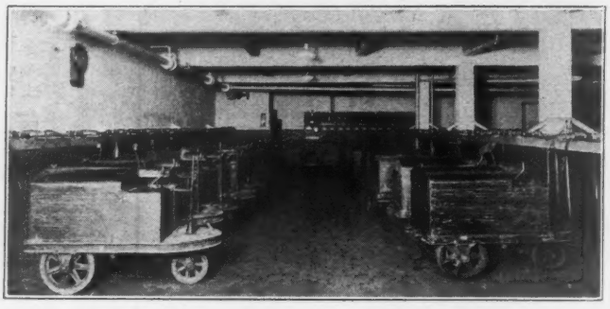
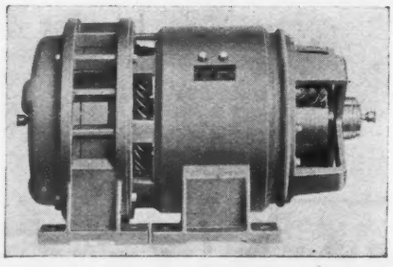


Mean Low Up-Keep Costs

Quite as important as the selection of the proper trucks to do your work is the selection of the Charging Equipment, to keep your trucks in perfect operating condition.

Your plant conditions may be changing.



Additional charging stations may mean economy for you.

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Utilize the experience of our engineers—their advice is yours for the asking.

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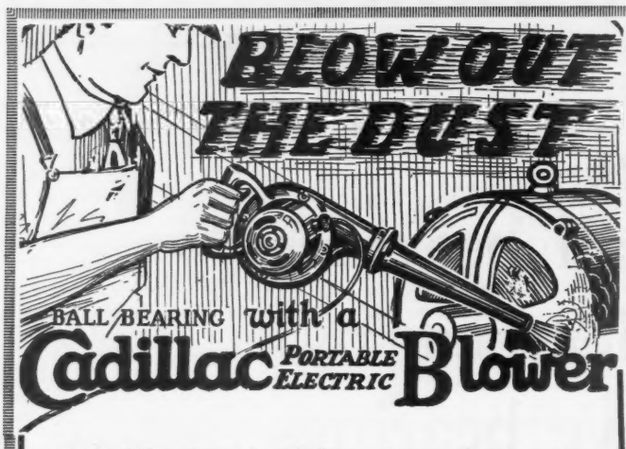
The HERTNER ELECTRIC COMPANY
W. 113th Street Cleveland Ohio U.S.A.



BALL BEARING with a
Cadillac PORTABLE ELECTRIC Blower

IT PAYS to keep the windings of your electric motors free from dust, dirt and carbon, and thus prevent "shorts" and "burn outs". The CADILLAC delivers a powerful blast of dry air at the correct pressure to clean motors and similar equipment without injury.

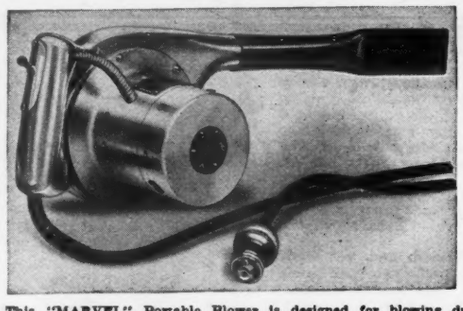
It reduces the fire risk and creates more healthful working conditions, and has hundreds of uses in the power plant and factory.

It weighs but a few pounds, is complete in itself and operates from any electric light socket.

Equipped with NORMA Precision Ball Bearings. Requires no oiling.

Write for descriptive folder giving prices and testimony of prominent users.

CLEMENTS MFG. CO.
617 Fulton Street, Chicago, Ill.
Canadian Factory: 76 Duchess St., Toronto, Ont.
Export Department: 149 Broadway, New York City, N. Y.



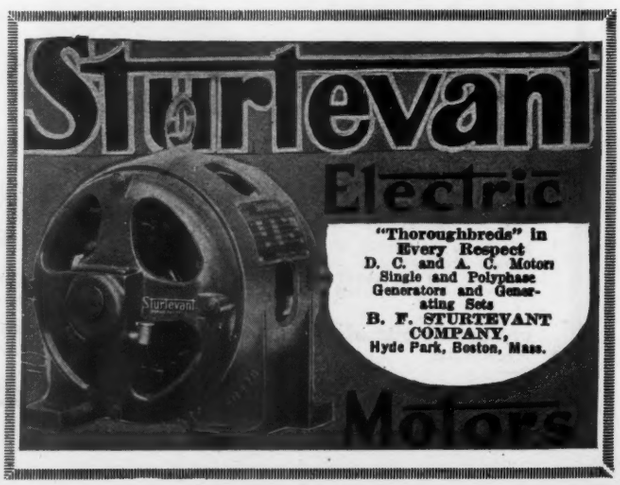
6½ lb. Air Cooled BALL BEARING Motor

Shipped on 10 days' trial, ANYWHERE

$40.00 Net Retail

This "MARVEL" Portable Blower is designed for blowing dust and dirt out of MOTORS, GENERATORS, SWITCHBOARDS, LOOMS, KNITTING and other TEXTILE MACHINERY, as well as for GAS BLOW PIPES, GAS FURNACES, ETC. Has 20 feet high grade cable and armored plug.

Manufactured by
ELECTRIC BLOWER COMPANY
352 Atlantic Avenue Boston 9, Mass., U. S. A.

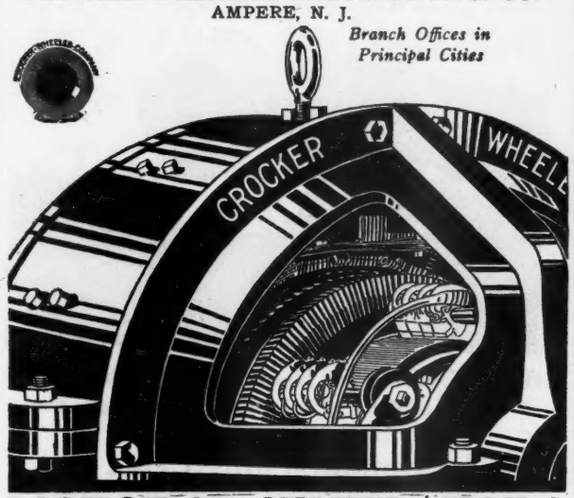


CROCKER-WHEELER

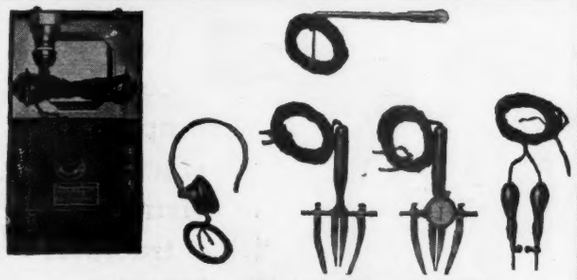
No cloak of mystery enshrouds the "why" and "wherefore" of the unfailing dependability of C-W Motors and Generators. Plenty of copper. Heavy frames. Old-fashioned thoroughness in manufacture. Lasting construction can't be hidden.

D.C. and A.C. Motors from ½ H.P. up.
D.C. and A.C. Generators and Motor-Generator Sets from 100 Watts up.

CROCKER-WHEELER ELECTRIC MFG. CO.
AMPERE, N. J.
Branch Offices in Principal Cities

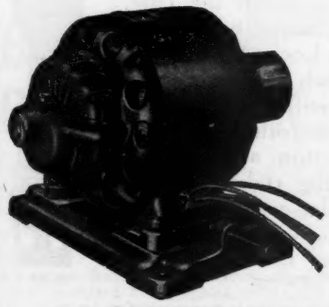


MOTORS & GENERATORS



CENTURY ARMATURE TESTER
Complete with all testing tools as illustrated $40.00.
Lamp, extra $2.25

CENTURY ELECTRICAL COMPANY
Manufacturers of Armature and Field Coil Testing Apparatus
Syracuse, N. Y.



Jeannin
Single Phase
Repulsion
Induction
Motors

¼ to 5 H. P.

The Jeannin Electric Co.
Toledo, Ohio

The First 15 Sold 50 More

AN original installation of 15 Valley Motors was placed in the factory of the Lampe Shoe Company the middle of 1922.

The work which these motors have to do consists of the pulling of line shafts, floors, and individual type shoe machine units. They run continuously all day long, and they are subject to frequent considerable overloads.

Since these motors were installed their performance has been so completely satisfactory that the management of this factory has installed more than 50 additional motors and assures us that future motors will be Valley Motors.

This is only another illustration of the service and satisfaction which buyers regularly get from Valley Ball Bearing Motors.

The delivery of continuous power with unusual operating economy and complete operating satisfaction is all in the day's work for Valley motors.

Before you buy or recommend another installation of motors, it will pay you to get all the facts about Valley Ball Bearing Motors. Write for descriptive booklet.

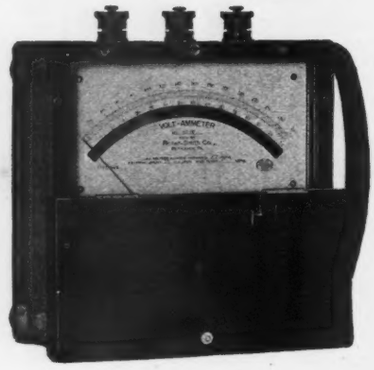
Motor Division
VALLEY ELECTRIC CO., ST. LOUIS, U S. A.
Branches in Principal Cities

Valley Electric

ROLLER-SMITH

TYPE GSD

VOLT-AMMETER



A combination instrument that you cannot afford to be without

For the plant that wants trustworthy testing instruments at the lowest possible cost — this ROLLER-SMITH Type GSD direct current Volt-ammeter is of inestimable value. For all around general service in factories, laboratories and educational institutions this instrument is unsurpassed.

The ROLLER-SMITH GSD instruments are recognized in every industry as much needed aids to efficiency. This GSD Volt-ammeter is a real combination portable D.C. Volt-ammeter that takes up the space of only one instrument and yet costs much less than two separate instruments. Of convenient size, light-weight, rugged and—above all—accurate and reliable, it does double the work—for only a little more than half the investment.

Ranges up to 750 amperes and 750 volts in all sorts of combinations.

The Type GSD Volt-ammeter and other Type GSD instruments are fully described and listed in Bulletin A-210.

Your copy is ready for you. Use the coupon.

"Over thirty years' experience is behind every ROLLER-SMITH product"

ROLLER-SMITH COMPANY

Electrical Measuring and Protective Apparatus

Main Office:
229 Broadway, NEW YORK

WORKS:
Bethlehem, Penna.

Atlanta	Cleveland	Memphis	Salt Lake City
Baltimore	Dallas	Montreal	San Francisco
Bethlehem	Denver	New Haven	Seattle
Birmingham	Detroit	New Orleans	St. Louis
Boston	Havana	New York	St. Paul
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Request for Roller-Smith Bulletin A-210

Name.....

Address.....

Company.....

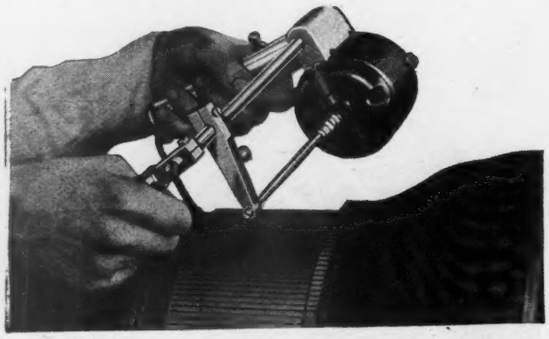
City.....

State.....

Will be sent ON TRIAL so You can Judge its Merits

You can try a Hullhorst Mica Undercutter in your shop for ten days, and determine whether it is capable of doing the most efficient undercutting, in quickest time, at lowest possible cost.

Simply write "on 10 days' trial" on your order and mail it now. Or we'll gladly send descriptive pamphlets on our three types of undercutters, if you prefer.



HULLHORST Mica Undercutter No. 6, $44.00

Saves 75 to 90% of Time and Labor

The Hullhorst Micro Tool Co.

DEPT. 2 **TOLEDO, OHIO**

For controllers, compensators, starters, trucks, tractors, cars, etc.

Trigger-Lock Fingers with renewable tips.

Contact worn out? Costly renewal necessary? This is often the case with the ordinary finger, but not so with the Trigger-Lock Finger. It carries a tip which is easily and quickly reversed without removing the finger from controller. The finger has a spring action, a more delicate contact, giving reduced wear on all the controller segments.

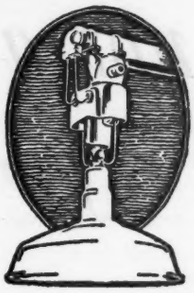
Learn about the many advantages of the Trigger-Lock Finger. Let us mail you valuable, illustrated catalog.

R-28

RUSSELL MANUFACTURING CO.

814 Bath Avenue **NIAGARA FALLS, N. Y.**

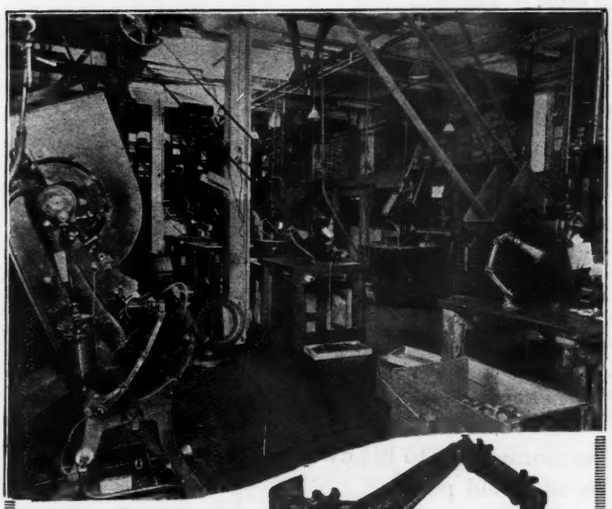
232 Westmount Drive **TORONTO, CANADA**



It's the Polish on the business side of the reflector that puts the light where you want it

And the Thompson Safety Lowering Switch solves the reflector cleaning problem. It enables the work to be done on the ground *easily* and safely. How? Get Catalog B-25 for details of this inexpensive device.

The Thompson Electric Co.
1438 W. 9th St. Cleveland, O.



BOOST PRODUCTION

6 STYLES
Ceiling Fixtures
Wall Brackets
Floor Fixtures
Bench Fixtures
Machine Fixtures
Portables

If your production is falling off and your employees are listless and indifferent—look to your lights! Good light—localized light—is an essential of greater production.

American Adjustable Fixtures, furnished with either standard flat brackets or conduit fixtures, are the real solution to the problem of Better Industrial Lighting.

Write now for our new catalog.

AMERICAN FIXTURE COMPANY
232 W. Water St. Milwaukee, Wis.

Showing ease of removing Reflector Two-Piece R. L. M. ABolite by simply compressing Spring in Neck.

Shallow Dome ABolite for wide angle distribution or general outdoor lighting.

Deep Bowl ABolite for concentrated light directly below reflector.

Angle Bowl ABolite for use where neither the R.L.M nor the Deep Bowl are practical. An ideal unit for window aand sign lighting.

Just as easy to change as it looks with the added advantage of having the proper illumination for each and every industrial requirement.

Our Catalog shows many other ABolite types of reflectors. Just ask for E-178.

A B Products Division

The NATIONAL SCREW & MFG. Co.
Cleveland, Ohio

Why not a Safety Zone in Industrial Selling?

The Peace Pact at Locarno—

forever bans war by setting up a safety zone between two traditional enemies. Neither can cross the "dead line" without bringing to the other's aid the arms of great neutral nations.

Why not a safety zone in industry beyond which the seller may know he cannot go without penalty of loss?

If every manufacturer who sells to industry would set up a safety zone which would clearly mark the border between profitable and unprofitable selling, he would take a step as momentous to his own business as Locarno is to world peace.

The McGraw-Hill Four Principles of Industrial Marketing are industry's safety zone. They safeguard profits as surely as the new Rhine barrier insures peace.

1926 is approaching. Some manufacturers will enter it with sales plans based on hunches. Others will enter with markets determined and programs outlined that will produce sales at the lowest cost.

Which plan will you follow?

IF YOU ELECT to apply the McGraw-Hill Four Principles of Industrial Marketing, here are the steps to take:

1. *Market Determination.* Study each market for your product. Weigh its potential. Determine which industries are the profitable ones to cultivate. The place to start is with your own books. Classify your sales by natural buying groups. Then compile data on each industry in which your product can be used. Compare the two and you will see clearly where your biggest opportunity lies.

2. *Buying Habits.* Study the buying habits of the industries you decide to sell. Find out who are the buyers and how they buy. This will save the expense and wasted effort of "barking up the wrong tree."

3. *Channels of Approach.* Having located the real buyers direct your selling on them. Support your sales effort with advertising in the publications which have the greatest influence with these buyers—the ones they look to for information.

4. *Appeals that Influence.* Don't talk generalities in your advertising. Talk shop in the buyers' own language. Tell them how your product will increase the productiveness of their plants or will reduce costs. Performance facts are what interest them most.

Here you have a plan for successful selling which is simplicity itself. There is no patent on it, for the McGraw-Hill Four Principles of Industrial Marketing are plain common sense, coded and applied to the job of selling to industry.

1926 is approaching. If you want to apply the McGraw-Hill Four Principles of Industrial Marketing to your 1926 program, follow the above formula. If you need guidance, the McGraw-Hill Company may be able to help you. Obviously we cannot develop sales plans for many, but we can supply information and suggest methods which will make simpler a manufacturer's own plan building.

Fifty years of intimate contact with industry have given us a knowledge of markets and buying habits which is proving of great value to many manufacturers.

1926 is approaching. If we can be of service to you, please feel free to call on us. Our book "Industrial Marketing" will give you a good start. It will be sent gratis to any manufacturer who sells to the industries covered by the Mc-Graw-Hill publications.

This advertisement is the seventh of the series which is appearing in the *New York Times, Philadelphia Public Ledger, Pittsburgh Gazette-Times, Chicago Tribune, Cleveland Plain Dealer, Detroit Free Press, Chicago Journal of Commerce* and *New York Herald-Tribune;* in *Printers' Ink, Advertising and Selling Fortnightly, Class, Sales Management,* and in the McGraw-Hill Publications. The purpose of these advertisements is to arouse a national appreciation of the need for improving industrial sales efficiency, and to awaken a keener interest in the correct principles of industrial selling.

McGRAW-HILL COMPANY, INC., NEW YORK, CHICAGO, PHILADELPHIA. CLEVELAND. ST. LOUIS, SAN FRANCISCO, LONDON, PUBLISHERS OF

Mc GRAW-HILL PUBLICATIONS

REACHING A SUBSTANTIAL MAJORITY OF THE POTENTIAL BUYERS IN THE INDUSTRIES THEY SERVE

Mining
ENGINEERING & MINING JOURNAL PRESS
COAL AGE
Radio
RADIO RETAILING
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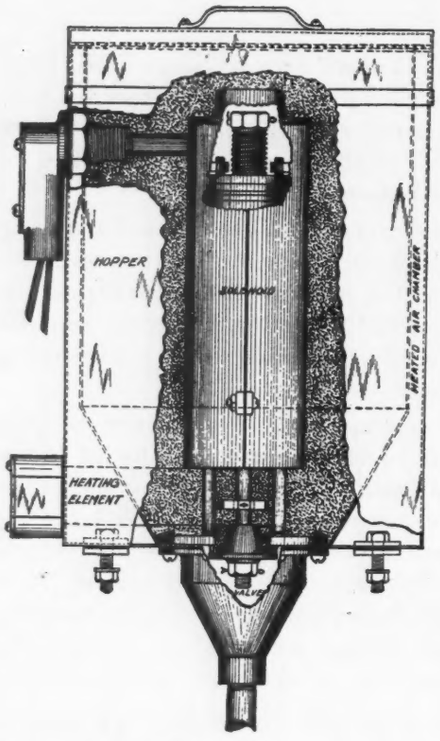
Electrical
ELECTRICAL WORLD
JOURNAL OF ELECTRICITY
ELECTRICAL MERCHANDISING

Industrial
POWER • AMERICAN MACHINIST
CHEMICAL & METALLURGICAL ENGINEERING
INDUSTRIAL ENGINEER

Overseas
AMERICAN MACHINIST (EUROPEAN EDITION)
INGENIERIA INTERNACIONAL

Construction & Civil Engineering
ENGINEERING NEWS-RECORD
Transportation
ELECTRIC RAILWAY JOURNAL
BUS TRANSPORTATION

N-L



Sand Runways without stopping the crane—

Do It Economically With

THE LINTERN ELECTRO MAGNETIC SANDER

The old hand-and-bucket method of sanding is dangerous and costly. By means of this modern sander you sand your tracks on the instant and actually prevent skidding, wheel spinning and those strains to crane and runways that mean expense—you bring safety into sanding in its highest degree—you keep your cranes in continuous operation.

The Sanders are operated by an N-L Momentary Contact Switch (by hand or foot) located in the operating cage of the cab. When pressure is removed, the sander valves automatically and immediately close.

Your request will bring our details.

THE NICHOLS-LINTERN CO.
7960 Lorain Avenue Cleveland, Ohio

Represented in Canada by Railway & Power Engr. Corp.
Toronto, Ontario

FA First Always

Here Is Insurance Against Costly Shut-Downs

Insurance—because there are no shut-downs from panelboard trouble when FA Panelboards are on the job. FA Panelboards could be built no better for your specific requirements if they were constructed according to your plans—and cost entirely disregarded. Every FA part is extra heavy, with an over amount of service built in. Every part is standardized. All work possible is done in the factory and FA Panelboards are complete when shipped. Installation costs are thereby lowered and FA Panelboards actually cost you less.

THERE IS A TYPE FOR YOU

Let us tell you about it. Write for details, descriptive FA catalog full of panelboard information and complete estimates. All furnished free!

Frank Adam
ELECTRIC COMPANY
ST. LOUIS

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Kansas City
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San Francisco
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Let's Get Acquainted
Write For This Book

FREE

No charge is made for Catalog D—a valuable data book and catalog of insulations. All we ask is that you state on your request what company you are identified with—or ask for it on your company letterhead.

TODD PROCESSES

are especially adapted to the manufacture of insulating varnishes. By its use deleterious substances are removed that cannot be taken out by other methods.

Sterling Varnishes are unusual because of their
elasticity combined with mechanical strength
endurance when exposed to service conditions
uniformity year in and year out
low cost due to the application of modern production methods

Avoid substitution, make sure that each package bears the mark "Todd Processes" as well as the word Sterling.

STERLING VARNISH
THE STERLING VARNISH COMPANY, PITTSBURGH, PA.

Insulating Varnishes and Finishing Enamels
our specialty

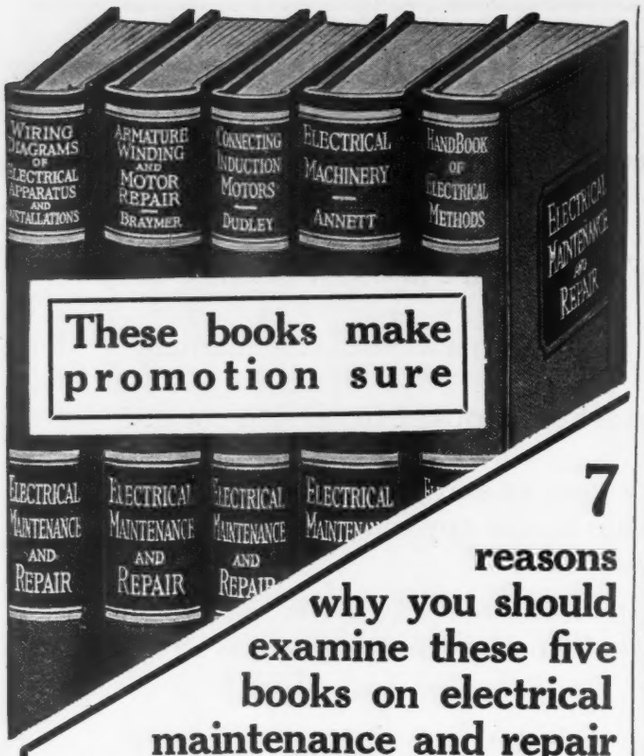
COIL VARNISH
CLOTH VARNISH
CORE PLATE VARNISH
MOTOR FINISHING ENAMEL
FLAT BLACK ENAMEL
TRANSFORMER PAINTS

Impregnating Compounds and Reducers
Baking Enamels for finish and durability are not excelled

Impervious Varnish Company
General Offices, Pittsburgh, Pa. **Works, Rochester, Penna.**

KLEIN TOOLS
Since 1857

Mathias Established 1857 **KLEIN** & Sons Chicago Ill USA


WIRING DIAGRAMS OF ELECTRICAL APPARATUS AND INSTALLATIONS
ARMATURE WINDING AND MOTOR REPAIR — BRAYMER
CONNECTING INDUCTION MOTORS — DUDLEY
ELECTRICAL MACHINERY — ANNETT
HANDBOOK OF ELECTRICAL METHODS
ELECTRICAL MAINTENANCE AND REPAIR
These books make promotion sure
ELECTRICAL MAINTENANCE AND REPAIR
ELECTRICAL MAINTENANCE AND REPAIR
ELECTRICAL MAINTENANCE AND REPAIR
ELECTRICAL MAINTENANCE

7 reasons why you should examine these five books on electrical maintenance and repair

1. The five books in this library discuss actual repair jobs and show you step by step what to do when anything goes wrong.
2. They show you how to locate and remedy motor and generator troubles.
3. They show you how to reconnect motors to meet any condition of voltage, phase, frequency and speed.
4. They give you suggestions for preventing electrical machinery troubles.
5. They cover fully the rewinding of motors.
6. They present information that will help you get better service out of your electrical equipment.
7. They give you tables, data, kinks and diagrams that you will find of priceless value every day on every job.

Free examination — no money down — only $2.00 in ten days and $2.00 a month until paid

Fill in and mail the coupon attached and we will send you the entire set of five volumes for ten days' Free Examination. We take all the risk—pay all charges. You assume no obligation—you pay nothing unless you decide to keep the books. Then $2.00 in ten days and the balance at the rate of $2.00 a month. Send the coupon NOW and see the books for yourself.

McGRAW-HILL

FREE EXAMINATION COUPON

McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York.

Gentlemen:—Send me the **Library of Electrical Maintenance and Repair,** all charges prepaid, for 10 days' Free Examination. If satisfactory I will send $2.00 in ten days and $2.00 a month until $14.00 has been paid. If not wanted I will write for shipping instructions.

Name .....

Home Address .....

City and State .....

Firm or Employer .....

Occupation .....I. E. 12-1-25

DRAGOMAN

No one in Egypt gives you a more hearty welcome than the dragoman.

He knows all languages, has melodramatic descriptive qualities and loves newcomers in direct proportion to the amounts they spend at the bazaars (on which he gets 10%).

He's a wonderful man while he keeps up his chatter, but your cold-grey-dawn analysis of him is that he's a big humbug.

Talk is a wonderful thing, properly handled, and it sells a lot of funny carbon brushes.

Morganite brushes, however, are not sold under the cloak of a spiffy story or through the din of a hearty laugh.

They are sold solely on performance and they themselves must deliver the sales arguments.

Morganite engineers prescribe a type of Morganite to fit the service *exactly.*

That type must save money for the user. If it doesn't then—But why continue, it *must* and it *does.*

That's that.

Morganite Brush Co., Inc.

Main Office and Factory
519 West 38th St., New York

DISTRICT ENGINEERS AND AGENTS

Pittsburgh, **Electrical Engineering & Mfg. Co., 909 Penn Ave.**
Cincinnati, **Electrical Engineering & Mfg. Co., 607 Mercantile Library Building.**
Cleveland, **Electrical Engineering & Mfg. Co., 422 Union Building.**
Baltimore, **O. T. Hall, Sales Engineer, 1926 Edmondson Ave.**
Revere, Mass., **J. F. Drummey, 75 Pleasant Street.**
Los Angeles, **Special Service Sales Co., 502 Delta Building.**
San Francisco, **Special Service Sales Co., 202 Russ Building.**
Toronto, Can., **Railway & Power Engineering Corp., Ltd., 101 Eastern Avenue.**
Montreal, Can., **Railway & Power Engineering Corp., Ltd., 326 Craig St., West.**
Winnipeg, Can., **Railway & Power Engineering Corp., Ltd., P. O. Box 325.**

For Dome Reflectors, 10″ to 24″

—For Deep Set Ceiling Lights, 10″ to 24″.

No. 91—Cone or Parbolic Shade. 6″ to 18″ diam., 2″ to 5″ depth.

Styles Nos. 280 to 288, depth 1-3 diam., 12″ to 24″. With or without locks.

Styles Nos. 290 to 298, depth 1-4 diam., 6″ to 16″ diam. With or without locks.

Style No. 51—Heavy Ceiling Guards Made with detachable flat iron rings. Also made with hinge and hasps 3″ to 22″ diam. 5″ to 16″ depth.

No. 54—Heavy Foundry or Wall Guards—Well stayed all around. Opens on hinges. 11″x5″x5″, 12″ x6″x6″.

Style No. 180 — "Webster" Cluster Guards. Depth 1-2 diam.; lightweight made with bolt clamp; 10″ to 24″. Heavy with hinge, etc.

Send today for our catalog and price list.

You can now get Morse Guards for industrial lighting reflectors

Our line of lamp guards has been expanded to include heavy, well made guards for dome reflectors and ceiling lights in mills, railroads, industrial plants, etc.

All guards are made so rigid that when fastened around the reflectors they are as strong and solid as part of the reflector itself. Hinges and hasps are furnished on all wire guards for ceiling lights.

Our regular stock guards fit any style reflector from 6 inches to 24 inches diameter and from very shallow depths up to 18 inches.

Special guards made to order.

Frank W. Morse Company

289 Congress St., Boston, Mass.

"MEG" Insulation Tester

Engineers who "Megger" tell us that the "Megger" Method is the best way of checking the condition of electrical equipment and of preventing unexpected breakdown.

The "Meg" Insulation Tester is our newest and most convenient device for the purpose. It is inexpensive and reliable. You merely connect one terminal to ground and the other to the conductor of a motor, generator, wire, transformer or cable, turn the crank at about 120 r.p.m. and read the scale—no calculations. Anyone can perform the test; and it gives information which cannot be obtained as easily in any other way.

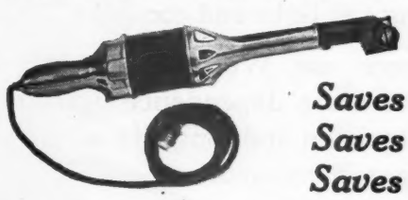
The "Meg" is a "Megger" of small size and light weight which generates 500 volts d.c. and reads up to 100 megohms. Try it and you will find, as many others have found, that it pays for itself very quickly.

The "Meg" is housed in a neat aluminum case as shown, it stands 6¼″ high and weighs 6¼ lbs. Price including canvas carrying case $135, f.o.b. Philadelphia.

Write for Pocket Manual 1060-E: Concerning Insulation Testing With Special Reference to the "Meg"

JAMES G. BIDDLE 1211-13 Arch Street PHILADELPHIA, PA.

Aurand Commutator Slotter



Saves Time
Saves Labor
Saves Expense

Undercuts mica in a fraction of the time it takes to do the job by hand.

Follows the line of mica and will operate over ridges. Cuts smooth to a uniform depth. Eliminates the necessity of removing armature and placing in a lathe, saving time and attendant danger of damage.

Made in two models

"The Aurand" for large commutators and heavy duty.

"The Aurand, Jr." for small commutators and light duty.

Hand operated, motor driven, portable, Universal type motor furnished for 110, 220, 250 or 275 volt services.

OTHER GREEN EQUIPMENT

ACME Commutator Stones
ACME Commutator Cement
ACME Commutator Polish
ACME Armature Washing Fluid
EMERY 4 Cyclone Blowers and Vacuum Cleaners
L. & H. Turning and Grinding Tools

Just drop us a line and we will tell you all about our Free Trial Offer.

Green Equipment Corporation

330 So. Dearborn Street **Chicago, Ill.**

PORTABLE
Precision in
ELECTRICAL MEASUREMENTS

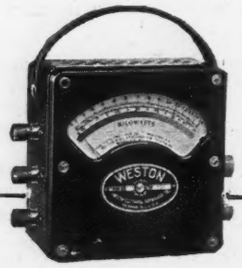
Weston Model 433
Portable Voltmeter

FREQUENTLY power losses and breakdowns occur at remote points and at inopportune times—yet it is possible to take anywhere—accurate, dependable testing equipment for thorough-going measurement in the field—Weston Juniors.

Weston Junior Portable Instruments consists of Voltmeters, Ammeters and single phase Watt-meters, of a small convenient size. They are contained in Bakelite cases meant for rough handling yet light and compact.

Engineers use Weston Juniors with the same dependence upon their precision and long-life as in the larger instruments.

Weston Model 432
Portable Voltmeter



For further information address

WESTON ELECTRICAL INSTRUMENT CORPORATION

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STANDARD THE WORLD OVER
WESTON
Pioneers since 1888

A Victim-
but Unaware!

THE insidious thing about unsterilized wiping rags is that their lurking danger cannot be seen. There may be millions of disease carrying germs in the folds of the whitest wiper—*if it has not been properly treated*—ready to attack any minor cut or injury. Your workers pay the toll with lost members or disease; and the consequent disrupted working forces make your production costs soar.

Kleen Kwality Kloths
Sterilized, Lintless

Kleen Kwality Kloths are sanitary—and lintless too. They are washed in chemicals, boiled in live steam and then baked at 225° F. That's the reason they are as sterile as hospital gauze. You can get these wipers in any quantity, from 10 lb. packages to 1,000 lb. bales. Specify them—they cost no more.

AARON FERER & SONS
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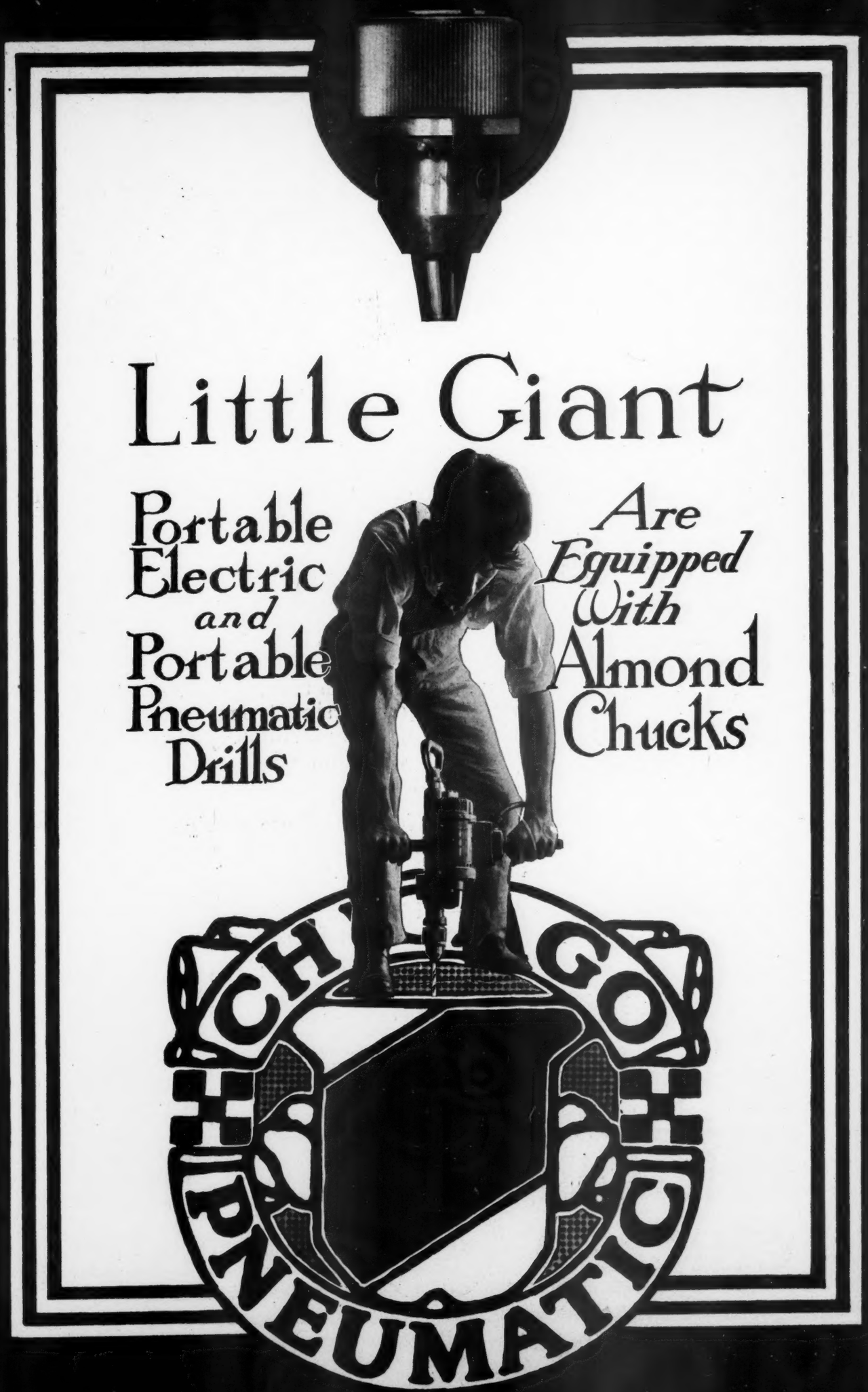
Branches in main industrial centers of U. S. A.

This mark is Your Guarantee of Sterilization. Demand It!


Little Giant
Portable Electric and Portable Pneumatic Drills
Are Equipped With Almond Chucks
CHICAGO PNEUMATIC

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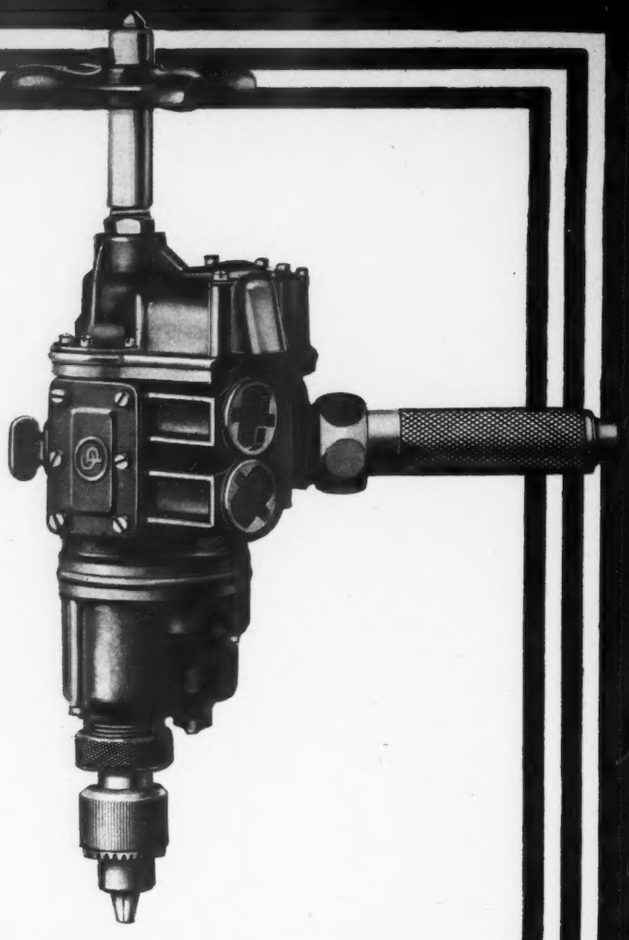

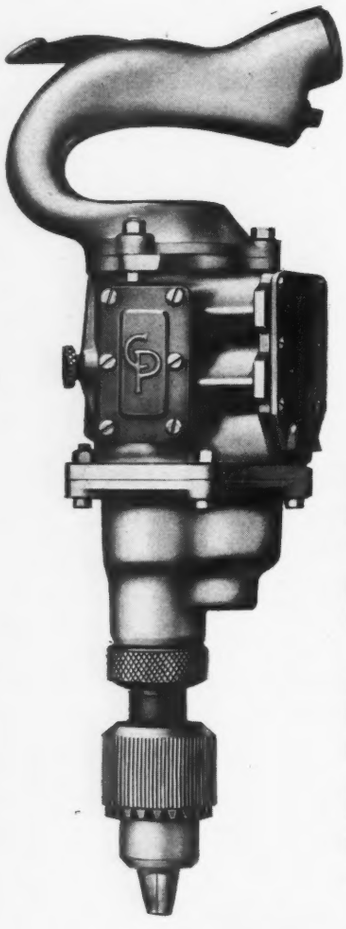

Husky, powerful ball bearing drills—non-reversible and reversible types, with large variety of gear reductions, plain spur geared and compounded to meet every drilling condition.

Ideal drills for use where service is extremely severe—where no other tools can stand the pace.

Rugged—without excessive weight. Powerful—but not wasteful of power. Durable—economical to operate and maintain.

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*Sales and *Service Branches all over the World*

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10 Vital Strip Heater Points

1. Exceptional overload capacity.
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5. High wattage capacity per square inch.
6. Construction that withstands abuse of vibration.
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10. The absence of mica for insulation between resistor and sheath.

We carry 70 different heaters in stock. 26 similar to construction as shown—44 with both terminals at one end.

The Railway Utility Company of Chicago is the sole distributor of Chromalox Strip Heaters for use in heating of railroad and street cars in United States and Canada.

Send for booklet C-100-E, giving complete information on Chromalox units and heating data. Use coupon below for sample Chromalox Strip Heater.

Service—We ship from stock within 24 hours

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Trade Mark Reg. U. S. Pat. Off.

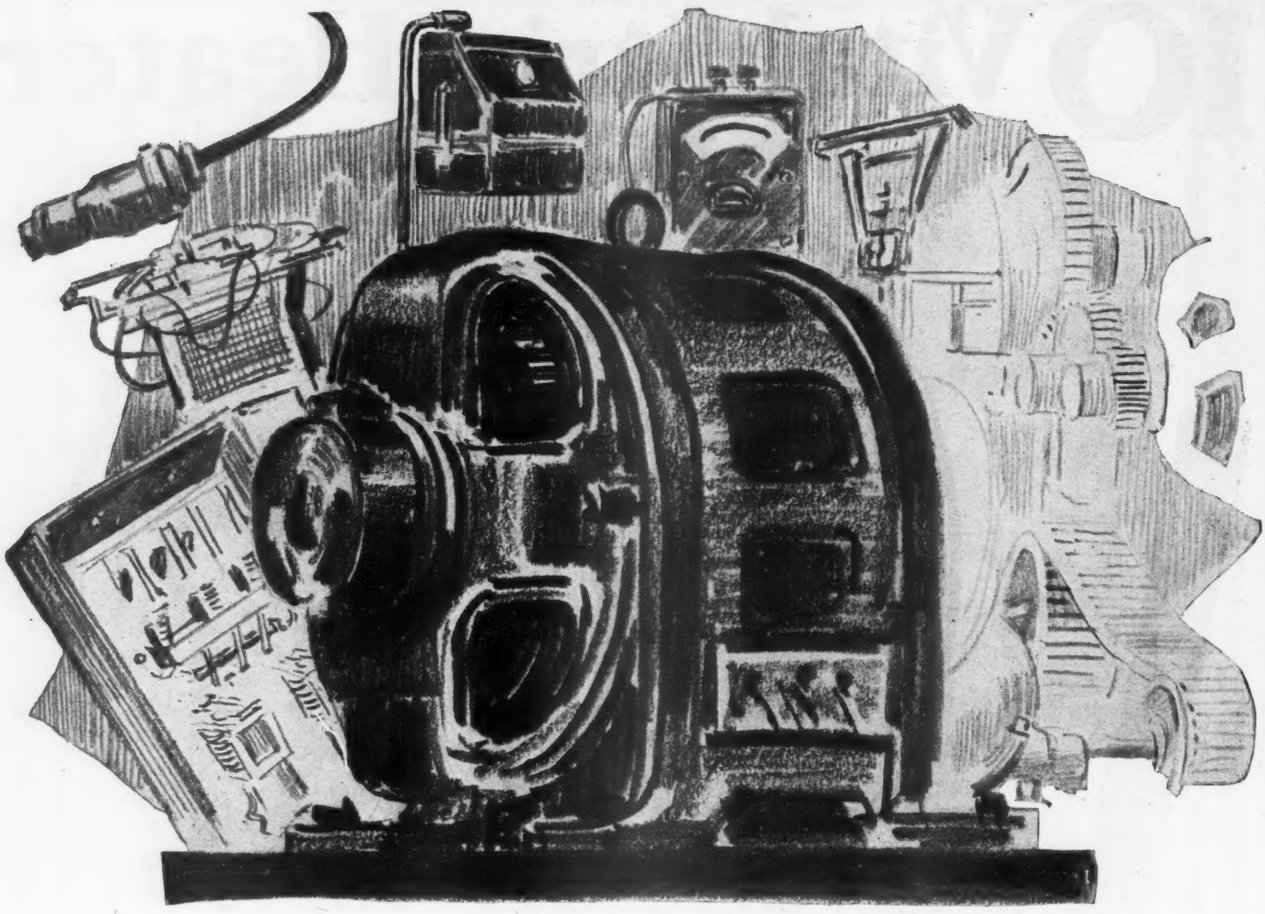
STRIPS

Let us prove our claim

EDWIN L. WIEGAND CO., 422 First Ave., Pittsburgh, Pa.
Please send me, without obligation, Chromalox Strip Heater for test and inspection. Also booklet C-100-E descriptive of same.

Company.....
Address.....
State.....
Attention.....

E



Look beyond the motor

Consider what a motor represents in conduit fittings, in switches, in starters, in wiring supplies, in line shafts, belts, chains, hangers, bearings, etc.

The motor is truly a gauge to a considerable market, and it is your problem to reach this market and tell your story to the operating men in the industrial plant. But reach the right men, the men who are responsible for the selection and operation of the electrical and mechanically related equipment.

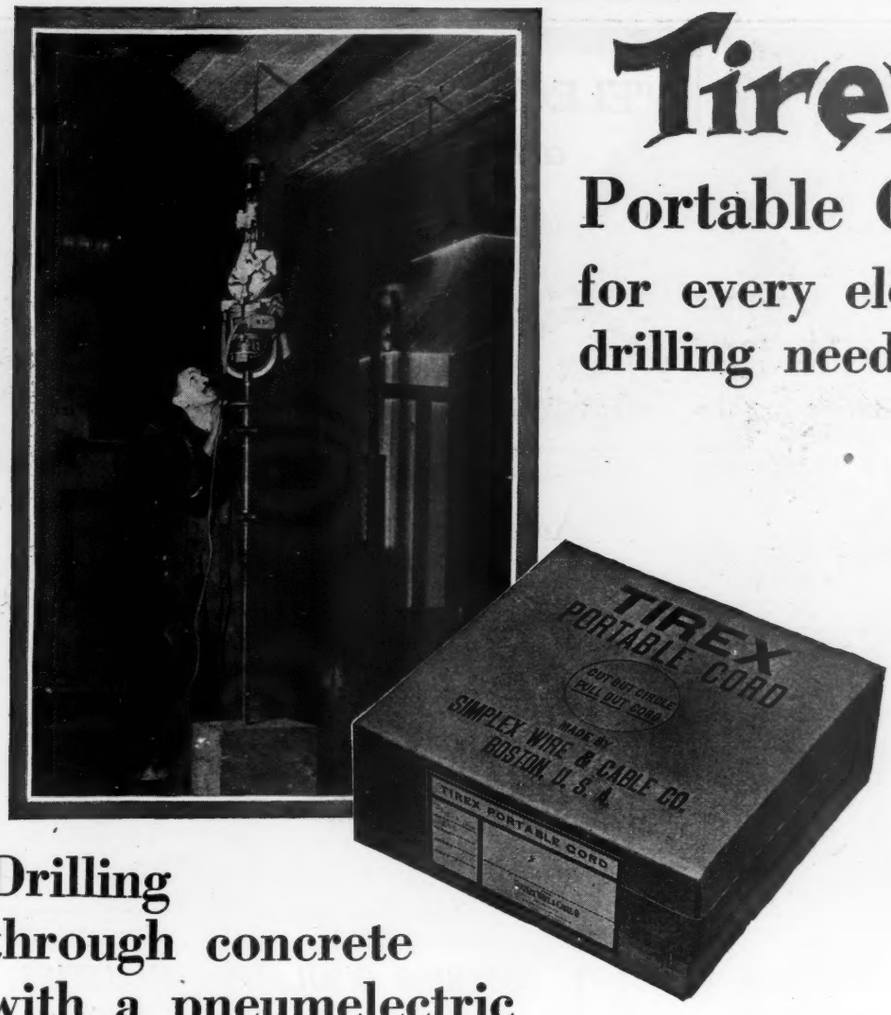
Industrial Engineer will take your message to the right men once a month. Consider it as a part of your organization.

Forms for the January issue close December 20th

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

A McGraw-Hill Publication. A.B.C.—A.B.P. 7 South Dearborn St., Chicago, Ill.



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Portable Cord for every electric drilling need!

TIREX NEVER KINKS

Drilling through concrete with a pneumelectric

The purchasing agent of a western factory writes us as follows:

"We are entirely pleased with the service that we have received from Tirex Portable Cord so far and from all appearances this cord will last indefinitely. We have made up our mind to specify Tirex hereafter for all the portable cord used in the factory."

On drills, grinders and all portable tools—Tirex does the job well and lasts a long time. It saves time because the tool is always on the job.

Sharp edges, rough ground, oil, grease or moisture have no appreciable effect upon TIREX ALL-RUBBER PORTABLE CORD. Tirex will stay on the job until the job is finished and will come back to the tool-room ready for more work. Send today for samples and prices.

If you are an electrical engineer, contractor or wireman, you need the Simplex Manual to help you in your daily work. The Simplex Manual contains, in addition to information regarding Simplex Products, tables and data for ready reference. One hundred sixty-four pages of valuable, condensed information—and it fits right into your pocket.

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Simplex Wire & Cable Co.,
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Gentlemen:—

Please send me the Simplex Manual. ☐

Please send quotation on Tirex Portable Cord. ☐

Size.....No. of Conductors.....

Voltage.....Feet.....

Name.....

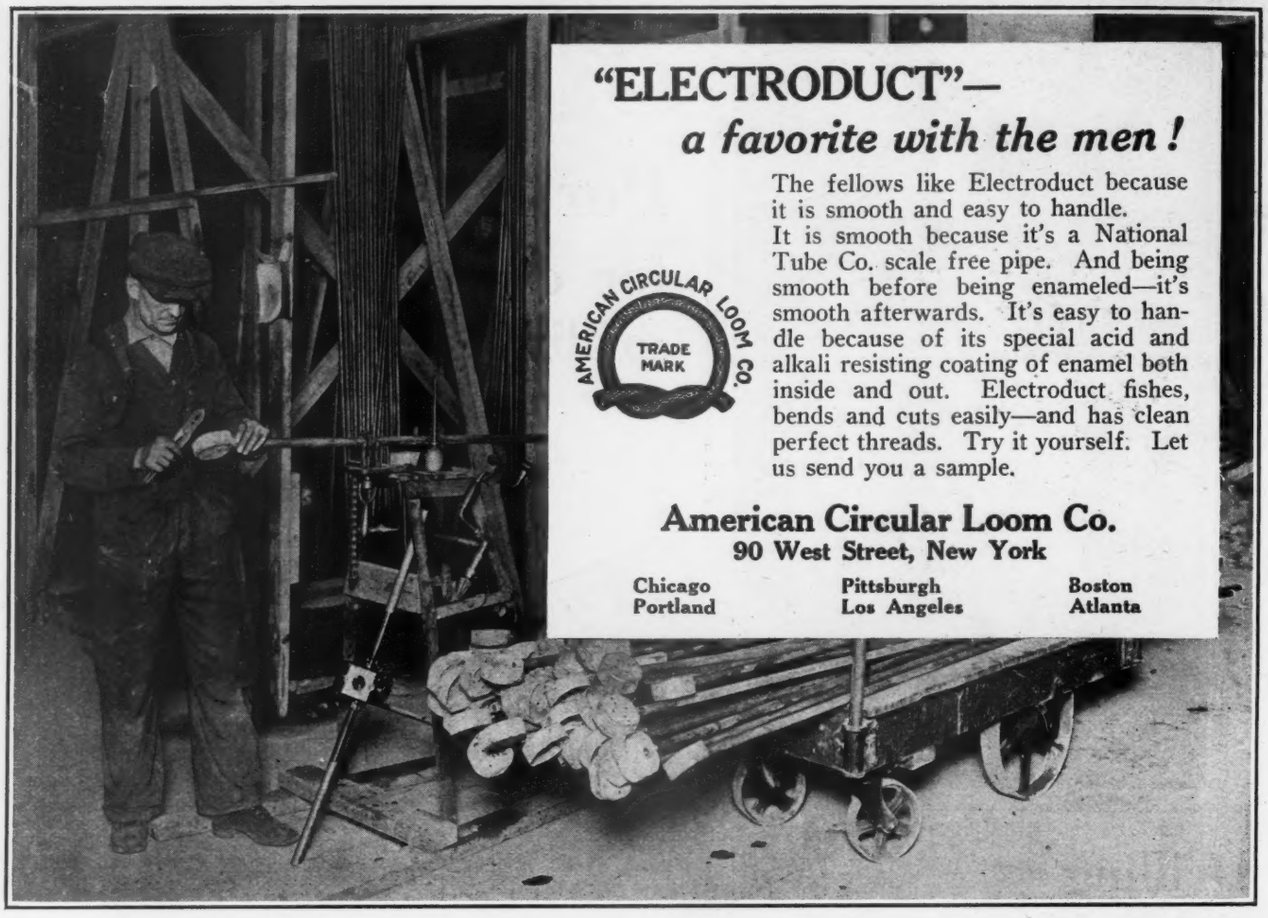
Position.....

Company.....

Address.....

City.....

State.....



"ELECTRODUCT"—
a favorite with the men!

The fellows like Electroduct because it is smooth and easy to handle.
It is smooth because it's a National Tube Co. scale free pipe. And being smooth before being enameled—it's smooth afterwards. It's easy to handle because of its special acid and alkali resisting coating of enamel both inside and out. Electroduct fishes, bends and cuts easily—and has clean perfect threads. Try it yourself. Let us send you a sample.

AMERICAN CIRCULAR LOOM CO. TRADE MARK

American Circular Loom Co.
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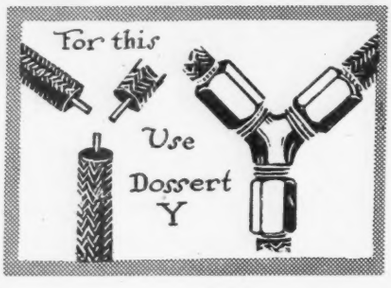
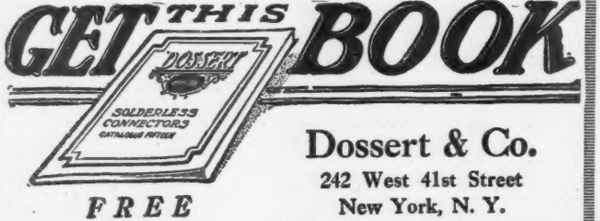


Y and wherefore

The why and wherefore of the acceptance of the Dossert line of connectors is summed up in the Dossert Tapered Sleeve principle.

This principle made possible the safe use of solderless connections.

Write for the Dossert 20th Year Book, showing the complete line.



Dossert & Co.
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Awebco Brand Tapes and Webbings make better insulation because they are most closely woven, are uniform in texture and free from defective spots or flaws.

Samples Free

Heavy Stay Binding .018 in. Thick

Use our sample book as your guide in choosing suitable weights and styles of insulation tape.

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The highly desirable finish on Salamander wires and cables is only obtained by using long asbestos fibres. These fibres do not require a cotton thread as a carrier during the insulating process, thereby avoiding the tendency of opening.

The resulting Salamander insulation gives a smooth, hard, continuous wall.

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This automotive starter brush is equipped with Belden Stranded Cable. Belden Cables are used extensively by brush manufacturers who demand extreme flexibility and uniform quality of production.

Use Belden Copper Cables

Stranded or Braided
For SWITCHES—GENERATORS—MOTORS

BELDEN Copper Cables are made of soft annealed copper strands. The number of individual strands vary from 24 to over one thousand in a single cable, the larger number of strands being used for extreme flexibility.

Belden facilities for manufacturing these special cables are extensive and complete, and inquiries are solicited from manufacturers, electric railways, and other users of stranded and braided flexible cables. Complete specifications and prices will be furnished for any type of cable, on request.

Specify Belden Magnet Wire

Belden facilities for manufacturing magnet wire permit an output exceeding 200,000,000 feet of magnet wire each week. The entire manufacturing process from wire mill to enameling or insulating, is carried on in our own departments.

Beldenamel wire is extensively used, either with or without cotton insulation, for rewinding motors and generators. Our engineering data book on Beldenamel wire describes the uses and advantages of Beldenamel, Cotenamel, and Silkenamel, and contains interesting engineering curves and tables. Send for it, TODAY!

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Kindly send us descriptive literature on Belden flexible cables. Also enclose your engineering data on Beldenamel Magnet Wire.

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The insulation makes all the difference in the world.

Repeated checking at every step in its manufacture assure you that Maring Wire is insulated for keeps. Send for sample.

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Put American Magnet Wire, enameled, cotton or silk insulation, to the test, just once, and you will see why industrial men who know always specify this wire. American Magnet Wire is always of uniform gauge.

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AMERICAN MAGNET WIRE
assures maximum service—finest results real economy

Order American Magnet Wire for your next requirements. You will standardize on it once you put it to the test. We will gladly send samples upon request.

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"OK" Weatherproof Wire
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Slow Burning Wire
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COTTON - ENAMEL - SILK - MAGNET WIRE — TRADE A-1 MARK

A-1 MAGNET WIRE

Plain Enamel, Single Cotton Enamel,
Single and Double Cotton Covered.

"AMERICAN BRAND"

Weather-proof Copper Wire and Cables
Slow Burning (Und.)
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Slow Burning Weather-proof Copper Wire and Cables
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Are representative of the highest principles in manufacturing and merchandising in the wire industry.

American Insulated Wire & Cable Co.
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WORCESTER BLEACH & DYE WORKS CO.

ESTABLISHED 1861

Bleachers, Dyers and Mercerizers of Cotton Yarns and Warps
Winding on Cops, Tubes or Cones
Manufacturers of Cotton Yarns in Fast Colors
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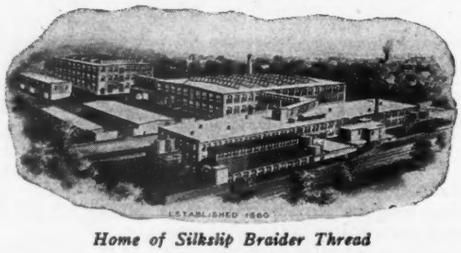
"Sewing and Stitching Threads for All Industries"



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WORCESTER, MASS.

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Coil making machines offer the latest in modern equipment for coil making.
Our machines are the simplest and less expensive and are being used by thousands of concerns throughout the world.
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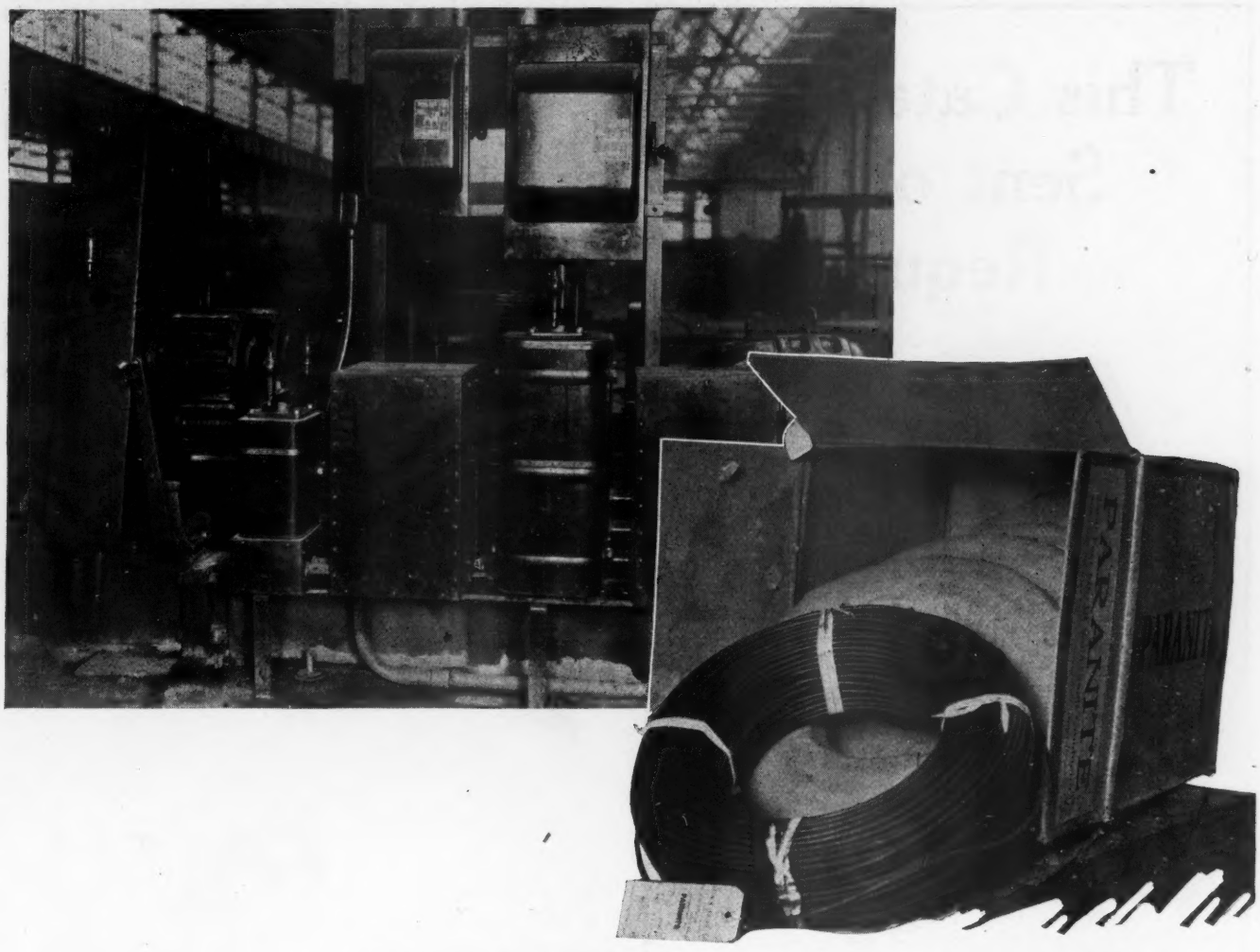

Consider the Life of the Wire

Industry is depending more and more on PARANITE for wiring requirements.

The reasons are simply that PARANITE insulation contains a liberal allowance of rubber and is "better than code requires." Economy is always an outstanding result where PARANITE is used from handling to the finished job. Give quality full consideration and make certain that PARANITE is used in those next wiring jobs.

Let us send you PARANITE samples. We give prompt service at all times.

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it's right

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The new WIREMOLD CONDUIT SYSTEM CATALOGUE AND WIRING GUIDE which gives complete practical installation information for installing WIREMOLD on the various kinds of wall and ceiling construction will be gladly sent on request.

Wiremold is the established standard for surface wiring and is inexpensive to buy—easy to install and makes a sturdy good looking job.

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Approved by Underwriters Laboratories and Associated Factory Mutual Fire Insurance Companies—carried in stock by leading electrical jobbers.

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Hartford, Conn.

Please send me catalogue and Wiremold Sample.

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"CIRCLE T" "R. M." TYPE SWITCHES for motors up to 7½ H. P.

Mr. Engineer:

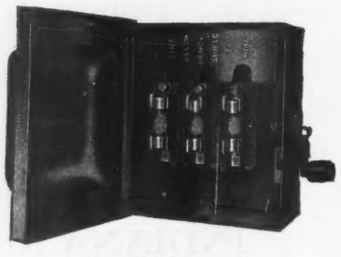
Our "R.M." line of motor starting switches is the lowest priced line on the market which will give you the service required in the Industrial Plant.

No. 94321 (Fig. 1)

Fig. 1 shows the two position motor starting switch which short circuits the fuses while motor is accelerating. For motors up to 5 H.P.

Fig. 2 shows the "R.M." type with inverse time protective cutouts for motors up to 7½ H.P., 440-550 V.

No. 93361 (Fig. 2)



No. 92321 (Fig. 3)

Fig. 3 shows the fusible type for small motors which can be thrown directly on the line with fuses in circuit.

Circular No. 2 describes in full our complete line of Motor Starting Switches.

THE TRUMBULL ELECTRIC MFG. CO.
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595 Mission St.

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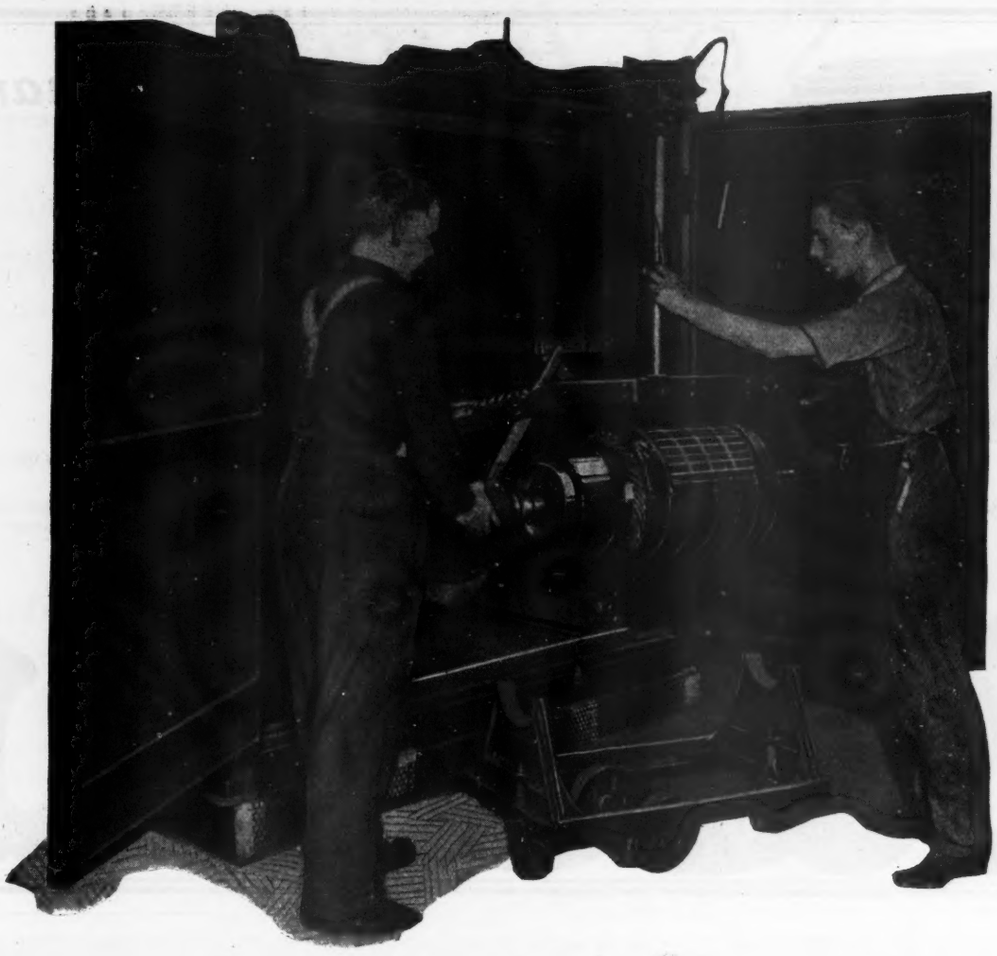

Armatures that bake longer last longer—

Thoroughness pays in overhauling armatures and coils, transformers, etc. A few hours added to the baking schedule will pay big dividends in longer life of the equipment.

"New fangled ideas" of doing just as good a job in less time with some fancy product that "somebody" has to sell will stand a thorough investigation. And an analysis will generally prove that instead of being better it is of poorer quality than claimed.

You can rest assured that in the twenty years since 1905 when Irvington started serving railways, mines and industrial plants, this company has looked after the best interests of its customers by constantly improving its product where it was possible.

Irvington Varnish & Insulator Co.
Irvington, N. J.

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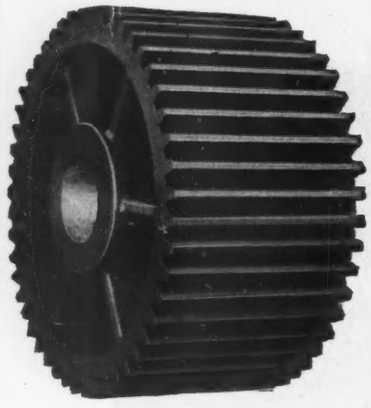
Today the Irvington Varnish and Insulator Company is the largest producer in the World of flexible varnished insulation. The quality and performance of Irvington Products no longer rests on claims or theoretical tests but on the long practical experience of leaders in electrical industry who have specified "Irvington" consistently during the past twenty years.

Such established standards of quality constitute a real safeguard. Write for the Irvington Insulation Book.



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If all the gears and pinions you broke or wore out last year had lasted four times as long, how much would you have been ahead today? Remember, Nuttall BP Gears are guaranteed to last four times as long as the ordinary kind.

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Nuttall

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Immediate Delivery from Stock

This is one of the hundreds of huge industrial plants where Imperial Commutator Stones are effecting a saving of from three to twenty times their cost by keeping commutators in proper working condition, avoiding delays, shutdowns and expensive repairs.

To eliminate sparking, ridges, high bars, high mica or flat spots, use Imperial Commutator Stones regularly.

Name.....
Firm.....
Address.....

Fill in and mail to receive free copy of new 16-page Catalog (No. 6).

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From A to Z*

You can pick your electrical supplies *out of this list*

The man who buys power apparatus faces two questions:

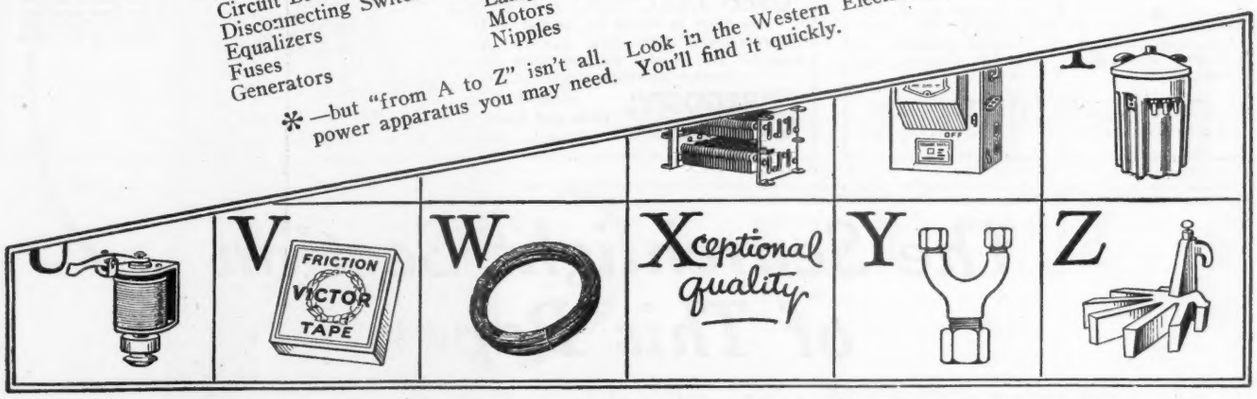
"Where can I buy it?" It may be a welcome fact to know that Western Electric stocks cover every power apparatus requirement from A to Z. The Western Electric Year Book, listing hundreds of items in simplified order, makes it possible to locate a desired power apparatus unit at a moment's notice.

"When can I get it?" No less important is the answer to this question—that Western Electric carries ready for immediate shipment large stocks of motors, control, switches, and other power apparatus. Quick delivery from a nearby distributing house is a big feature of Western Electric service.

And, of course, the biggest feature is that Western Electric supplies come to you with the indorsement of over half a century of electrical experience.

Ammeters
Bus Bar Supports
Circuit Breakers
Disconnecting Switches
Equalizers
Fuses
Generators
Hangers
Insulators
Junction Boxes
Knife Switches
Lamps
Motors
Nipples
Oiled Silk
Panels
Quick Delivery
Resistors
Square D Switches
Transformers
Undervoltage Attachments
Victor Tape
Wire
Xceptional Quality
Y—Connectors
Zincs, Battery

*—but "from A to Z" isn't all. Look in the Western Electric Year Book for whatever power apparatus you may need. You'll find it quickly.



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QUALITY ELECTRICAL SUPPLIES

OFFICES IN 54 PRINCIPAL CITIES

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1 to 3 inches.....$5.00 an inch
4 to 7 inches..... 4.80 an inch
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I. E.

POSITIONS VACANT

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Get in the new profession. We can teach you meter engineering by mail at your own home during spare time. Successful graduates everywhere.

EARN $3,600.00 A YEAR

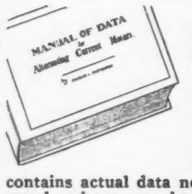
Central stations must have Electrical Meter Engineers. They pay high salaries. Write today. Just your name and address on a postal and we will send you full particulars free. Ft. Wayne Correspondence School, Dept. 80, Ft. Wayne, Ind.

D. C. EQUIPMENT

1—General Electric D. C. Generator, 15 KW., 250 volts, type RC29, speed 1700, 60 amps., with pulley and base. Price....$285.00

1—General Electric D. C. motor, 5 H. P., 230 volts, type RC 27A, amps. 19.1, speed 1150. No pulley or base. Price..... 165.00

RICHARDSON-WAYLAND ELEC. CORP.
Roanoke, Va.



A MANUAL OF WINDING DATA

A printed manual giving the actual rewinding data for two and three phase motors of twelve leading manufacturers. It contains actual data necessary to change the speed, phase, or horse power of A. C. Motors. Earns its cost quickly. We guarantee satisfaction or money refunded on return of manual. Ask for circular and samples.

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POSITIONS WANTED

ELECTRIC PLANT OPERATOR AND MAINTENANCE MAN Desires position in industrial plant affording opportunity for technically trained man. Three years' experience. Any location. Reference of qualifications on request. Married. Address—Technical Electrical Box No. 215, Salem, Oregon.

ELECTRICAL, POWER, CONSTRUCTION, OR MAINTENANCE ENGINEER. Industrial Plant. Eastern Location. At present employed. PW185, Industrial Engineer, 10th Ave. at 36th St., New York.

This National Electric Clearing-House

is THE "connecting-link" between those anxious *to move* equipment and those who are looking for bargains. List "your condition" with

R. P. McCONAHAY, Van Wert, Ohio

POSITIONS WANTED ADS

reach employers of technical men on the Pacific Coast. Use the

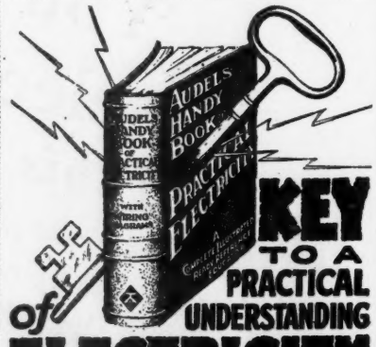
SEARCHLIGHT SECTION

USED ELECTRIC MOTORS

All Sizes in Stock Up to 250 H. P.
Reconditioned Like New and Guaranteed
Send for List Showing Complete Stock on Hand
MOTORS RENTED—EXCHANGED

GREGORY ELECTRIC CO. CHICAGO, ILLINOIS

Established 1893
16th and Lincoln St.
Chicago, Illinois



KEY TO A PRACTICAL UNDERSTANDING of ELECTRICITY

Audel's Handy Book of Electricity, Price $4.

A quick simplified ready reference, giving complete instruction and inside information. Handy to use. Easy to understand. For Engineers, Professional Electricians, Students and all interested in Electricity. A reliable authority and a handy helper for every electrical worker.

INFORMATION

The 1040 pages aand 2600 diagrams give accurate, up-to-date and complete information on—Rules and Laws, RADIO, Storage Batteries, WIRING DIAGRAMS, Power and House Wiring, Automatic 'Phones, Auto Ignition, Motor Troubles, ARMATURE WINDING, Cable Splicing, Elevators and Cranes, Sign Flashers, Transformers, Practical Management, Modern Applications—READY REFERENCE on every electrical subect. Pocket Size, handsomely bound in flexible Red LEATHER. Easy Terms. Shipped for Free Examination. No obligation to buy unless satisfied.

FREE EXAMINATION COUPON

The. Audel Co, 65 W. 23 St, NewYork
Please send me Audel's Handy Book of Practical Electricity for **free examination.** If satisfactory, I will send you $1 in 7 days, then $1 monthly until $4 is paid.

Name.....
Address.....
Occupation.....
Employed by ..... SL

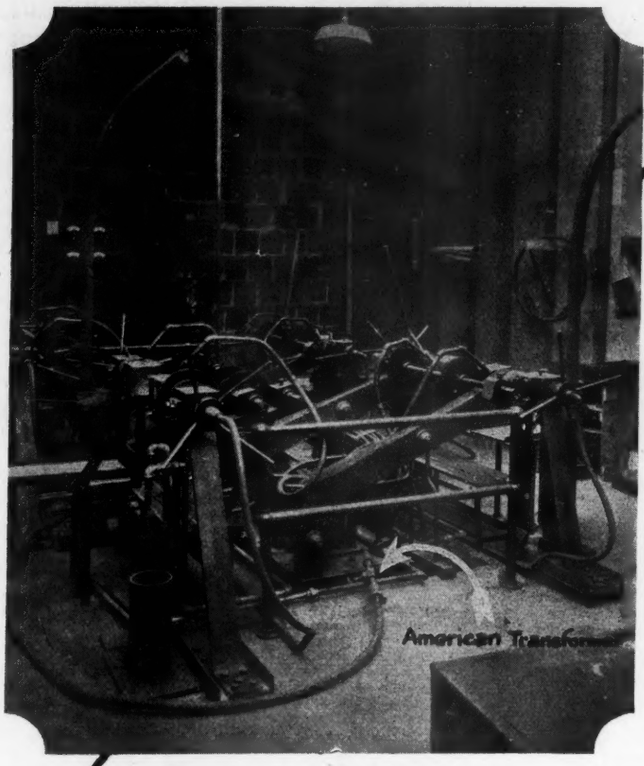
The Searchlight Section of This Paper

is devoted exclusively to the advertising of idle used and surplus new equipment, and all other business "Opportunities".

Buyers and others consult "Searchlight" ads for what they want.

You can reach them quickly and at small cost through an advertisement in the Searchlight Section.

American



Two American Transformers similar to the unit below deliver high current at low voltage for this furnace.

Again, the Ultimate Solution!

When the Hermas Machine Co., Hawthorne, N. J., built the new hydraulically operated furnace illustrated the transformer problem involved was one embodying many conditions with which transformer manufacturers in general could not cope.

For more than twenty-three years, however, the American Transformer Company has been building successfully, transformers for just such special applications as was required in this instance. The high efficiency and reliability which these furnace transformers are giving is characteristic of American Transformer installations.

In mills, foundries, and in general industrial plants all over the country there are American Transformers which are delivering the best of service and long uninterrupted operation in all kinds of work because they are correctly designed to meet the requirements of the particular process in which they are utilized.

Perhaps right at this minute you have a special problem that requires careful attention and involves economical utilization of power.

Whatever your needs, it will pay you to get the benefit of our experience. No obligation. Just address the company.

For your information we shall gladly send you Bulletins 1025 and 1030 which describe some of these transformers.

AMERICAN TRANSFORMER CO.
178 Emmet Street, Newark, N. J.

Transformers

WHAT AND WHERE TO BUY

Equipment, Apparatus and Supplies Advertised in this Issue with Names of Manufacturers and Distributors

Prospective purchasers in the electrical-mechanical market are invited to apprise us of their needs, assuming, of course, that the articles sought are not listed here.

INDUSTRIAL ENGINEER
7 South Dearborn St. Chicago

Air Compressors
Allis-Chalmers Mfg. Co.

Air Filters
Midwest Air Filters, Inc.

Ammeters, Voltmeters
(See Instruments, Electrical.)

Armature Coil Spreaders
Armature Coil Equipment Co.
Mutual Foundry & Machine Co.

Armature Coil Winders
Armature Coil Equipment Co.
Mutual Foundry & Machine Co.

Armature Repair Machinery
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Batteries, Dry
National Carbon Co.
Western Electric Co.

Battery Charging Apparatus
General Electric Co.
Hertner Electric Co.
Westinghouse Elec. & Mfg. Co.

Bearings

Ball
Fafnir Bearing Co.
Norma-Hoffman Bearings Corp.
Torrington Co., The

Roller
Dodge Mfg. Corp.
Hyatt Roller Bearing Co.
Norma-Hoffmann Bearings Corp.
Timken Roller Bearing Co., The.

Bearing Metal
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Bells, Electric
Schwarze Electric Co.
Westinghouse Elec. & Mfg. Co.

Belts, Conveyor
Link-Belt Co.

Belts, Transmission
Link-Belt Co.

Bleachers
Worcester Bleach & Dye Works Co.

Blocks, Pillow
Fafnir Bearing Co.

Blowers
Clements Mfg. Co
Electric Blower Co.
Green Equipment Corp.
Martindale Electric Co.

Bolts, Nuts and Screws
Sturtevant Co., B. F.

Books, Technical
Audel & Co., Theo.
McGraw-Hill Book Co., Inc.

Boosters
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Boxes

Conduit
Appleton Electric Co.
Johns-Pratt Co.

Floor Outlet
Adam Electric Co., Frank
Hubbell, Inc., Harvey

Junction and Outlet
Appleton Electric Co.
General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Meter and Service
General Electric Co.
Johns-Pratt Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Sectional, Switch & Outlet
Appleton Electric Co.

Brakes

Crane
Westinghouse Elec. & Mfg. Co.

Disc
Westinghouse Elec. & Mfg. Co.

Electric
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Brushes

Commutator
Baylis Co., The
Boxill-Bruel Carbon Co.
Calebaugh Self Lubricating Carbon Co.
Carbon Engineering Co.
Corliss Carbon Co.
General Electric Co.
Hohlman & Hill, Inc.
Jeandron, W. J.
Morganite Brush Co., Inc.
National Carbon Co.
Westinghouse Elec. & Mfg. Co.

Controller
Corliss Carbon Co.

Dynamic and Carbon
Boxill-Bruel Carbon Co.
Corliss Carbon Co.
Hohlman & Hill, Inc.
Jeandron, W. J.
Morganite Brush Co., Inc.
National Carbon Co.
Westinghouse Elec. & Mfg. Co.

Brush Holders
Baylis Company
Flower, D. B.
Westinghouse Elec. & Mfg. Co.

Bus Bar Supports
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Bushings
Appleton Electric Co.
National Metal Molding Co.

Cables (See Wire & Cable)

Cable Accessories
Dossert & Co.
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Carbon Brushes
(See Brushes.)

Castings, Steel
Falk Corp.

Cement

Commutator
Martindale Electric Co.

Chains, Power Transmission
American High Speed Chain Co.
Link-Belt Co.

Circuit Breakers
Condit Electrical Mfg. Co.
Cutler Hammer Mfg. Co.
Cutter Co.
General Electric Co.
Roller-Smith Co.
Sundh Electric Co.
Westinghouse Elec. & Mfg. Co.

Clamps
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Cleats
National Metal Molding Co.
Square D Co.

Cloth Wipers
Aaron Ferer & Sons

Clutches

Friction
Allis-Chalmers Mfg. Co.
Link-Belt Co.

Magnetic
Cutler-Hammer Mfg. Co.

Coal and Ash Handling Equipment
Link-Belt Co.

Coatings, Preservative
Sterling Varnish Co.

Coil Winding Machines
Armature Coil Equipment Co.
Belden Mfg. Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coil Winding Tools
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coils, Choke
American Transformer Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Coils, Induction
American Transformer Co.

Coils, Magnet, Field
Belden Mfg. Co.

Compensators

Automatic
Cutler-Hammer Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Manual
Allis-Chalmers Mfg. Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Conductors, Armored
Tubular Woven Fabric Co.

Conduits
American Circular Loom Co.
American Wiremold Co.
National Metal Molding Co.
Tubular Woven Fabric Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 92.

Connectors & Terminals
Belden Mfg. Co.
Dossert & Co.
General Electric Co.
Ohio Electric & Controller Co.
Westinghouse Elec. & Mfg. Co.

Contacts, Carbon & Metal Graphite
Corliss Carbon Co.

Control Systems
Monitor Controller Co.

Controller Fingers
Russell Mfg. Co.

Controller Regulators
Monitor Controller Co.

Controllers

Automatic
Allen-Bradley Co.
Industrial Controller Co.
Lewellen Mfg. Co.
General Electric Co.
Johns-Pratt Co.
Westinghouse Elec. & Mfg. Co.

Motor
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Lewellen Mfg. Co.
Monitor Controller Co.
Sundh Electric Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Rheostatic
Monitor Controller Co.

Speed
Monitor Controller Co.

Conveyors
Link-Belt Co.
Weller Mfg. Co.

Conveyors, Gravity
Standard Conveyor Co.

Cooling Air Filters
Midwest Air Filters, Inc.

Cord, Flexible
Belden Mfg. Co.
Hubbell, Inc., Harvey
Okonite Co., The
Rome Wire Co.
Tubular Woven Fabric Co.
U. S. Rubber Co.

Cotton Yarns
Worcester Bleach & Dye Works Co.

Couplings, Flexible
Allis-Chalmers Mfg. Co.
Dodge Mfg. Co.
Falk Corp.
Foote Bros., Gear and Machine Co.
Nuttall Co., R. D.
Smith & Serrell

Crane Controllers
Monitor Controller Co.

Crane Motors
Monitor Controller Co.
Sundh Electric Co.
Westinghouse Elec. & Mfg. Co.

Cranes, Portable Electric
Elwell-Parker Co.

Cross Arms
Electric Service Supplies Co.
Western Electric Co.

Cutouts
General Electric Co.
Hubbell, Inc., Harvey
Johns-Pratt Co.
Square D Co.
Trumbull Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Cutters

Hole
Koch & Co., Paul W.

Commutator Slotting
Hullhorst Micro Tool Co.

Diagrams, Winding
Chittenden, Charles L.
McGraw-Hill Book Co., Inc.

Silent Chain
American High Speed Chain Co.
Link-Belt Co.

Dynamos
(See Generators & Motors.)

Electric Lighting
Benjamin Elect. Mfg. Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Elevators & Conveyors
Link-Belt Co.
Weller Mfg. Co.

Enamels, Wire, Wood and Steel
Impervious Varnish Co.
Sterling Varnish Co.

Engineers, Illuminating
Westinghouse Elec. & Mfg. Co.

Engines Oil
Allis-Chalmers Mfg. Co.
Fairbanks-Morse & Co.
Falk Corp.

Factory Furniture
Westinghouse Elec. & Mfg. Co.

Factory and Mill Lighting
Westinghouse Elec. & Mfg. Co.

Fan Hangers, Electric
Adam Electric Co., Frank

Fan Motors
Century Electric Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Fans

Exhaust and Ventilating
Century Electric Co.
General Electric Co.
National Screw & Mfg. Co.
Star Electric Motor Co.
Westinghouse Elec. & Mfg. Co.

Files, Commutator Slotting
Martindale Electric Co.

Filters, Air
Midwest Air Filters, Inc.

Fittings

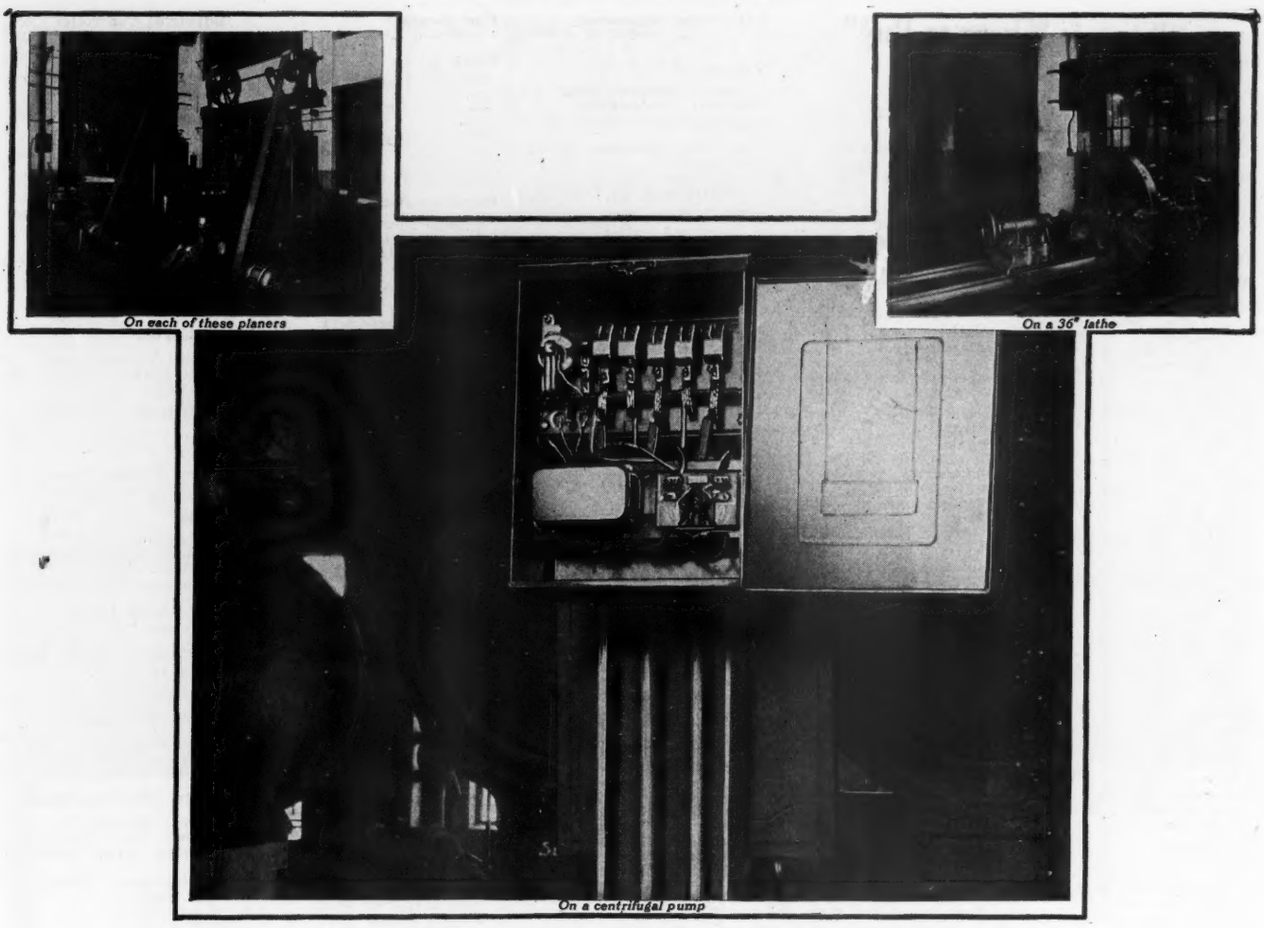
Conduit
Appleton Electric Co.
National Metal Molding Co.

Pipe
Westinghouse Elec. & Mfg. Co.

Fixtures, Lighting
American Fixture Co.
McGill Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Furnaces, Electric
General Electric Co.
Westinghouse Elec. & Mfg. Co.

(Continued on page 88)



Why This G-E Automatic Compensator is Popular

The CR7051-J1 Automatic Compensator for Squirrel Cage Induction Motors continues to gain favor. There are four outstanding reasons:

The Definite Time Accelerating Relay, which gets the motor on the line in the quickest possible time.

The Multiple Rated Auto Transformer applied for the first time by General Electric on a standard Compensator.

The unique method of mounting the starting and running contactors, providing ample access to both for inspection and replacement of parts, at the same time maintaining ease of installation.

The Temperature Overload Relay.

Shown above are four of 40 which the American Can Co. has installed on various machine tools; also one at the Warner Sugar Refining Co., which has been operating for 18 months in an atmosphere charged with salt, pulverized carbon, and lime.

The Industrial Control Specialist in your nearest G-E office can give you additional reasons for the popularity of this and other G-E Control Devices.

General Electric builds a type of control for every motor application. Each device has built into it the experience accumulated in the manufacture of all types of motors and control for more than 30 years.

9-13

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL PRINCIPAL CITIES

"What & Where to Buy"

(Continued from page 86)

Fuse Clips
Trumbull Electric Mfg. Co.

Fuse Plugs
Hubbell, Inc., Harvey
Westinghouse Elec. & Mfg. Co.

Fuses
General Electric Co.
Mfg. Co.
Johns-Pratt Co.
Trico Fuse Mfg. Co.
Renewable
Bussman Mfg. Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.
Johns-Pratt Co.

Gears
Dodge Mfg. Corp.
Falk Corp.
Foote Bros. Gear and Machine Co.
Link-Belt Co.
General Electric Co.
Nuttall Co., R. D.
Smith, Winfield H.
Westinghouse Elec. & Mfg. Co.

Composition
Chicago Rawhide Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Generating Sets
Allis-Chalmers Mfg. Co.
Crocker-Wheeler Co.
General Electric Co.
Marble-Card Electric Co.
Triumph Electric Co.
Westinghouse Elec. & Mfg. Co.

Generators
Allis, The Louis Co.
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Chandeysson Electric Co.
Crocker-Wheeler Co.
Electro-Dynamic Co.
General Electric Co.
Hertner Electric Co.
Reliance Elec. & Eng. Co.
Star Electric Motor Co.
Westinghouse Elec. & Mfg. Co.

Glue Pots
Westinghouse Elec. & Mfg. Co.

Grinders
Chicago Pneu. Tool Co.
Fafnir Bearing Co.
Martindale Electric Co.

Grounding Devices
Dossert & Co.

Hammers
Pneumatic
Chicago Pneu. Tool Co.
Rawhide
Chicago Rawhide Mfg. Co.

Hangers, Line Shaft
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Link-Belt Co.

Hangers, Safety, Disconnecting
Thompson Electric Co.

Heating Devices, Industrial
Campbell Mfg. Co.
General Electric Co.
Midwest Air Filters, Inc.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Hoists, Electric
General Electric Co.
Link-Belt Co.

Indicators, Speed
(See Tachometers.)

Instrument Transformers
American Transformer Co.
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.

Instruments, Electrical
Graphic
Esterline-Angus Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Indicating
Biddle, James G.
General Electric Co.
Roller-Smith Co.
Taylor Instrument Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't Corp.
Integrating
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Scientific and Testing Service
Biddle, James G.
Esterline-Angus Co.
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't Corp.

Insulating Material
Comp. Cloth and Paper
Belden Mfg. Co.
General Electric Co.
Sterling Varnish Co.
Westinghouse Elec. & Mfg. Co.
Compounds, Paints and Varnishes
Belden Mfg. Co.
Dolph Co., John C.
General Electric Co.
Impervious Varnish Co.
Irvington Varnish & Ins. Co.
Martindale Electric Co.
Sterling Varnish Co.
Westinghouse Elec. & Mfg. Co.
Fibre
General Electric Co.
Molded
Belden Mfg. Co.
Cutler-Hammer Mfg. Co.
Tape and Webbing
Anchor Webbing Co.
General Electric Co.
Okonite Co., The
U. S. Rubber Co.
Westinghouse Elec. & Mfg. Co.

Insulators
Electric Service Supplies Co.
General Electric Co.
Irvington Varnish & Ins. Co.
Square D Co.
Westinghouse Elec. & Mfg. Co.

Lamp Guards
Electric Service Supplies Co.
Hubbell, Inc., Harvey
Morse Co., Frank W.
Westinghouse Elec. & Mfg. Co.

Lamps
Arc
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Incandescent
General Electric Co.
Western Electric Co.
Nitrogen
Westinghouse Elec. & Mfg Co.
Trouble
Benjamin Elect. Mfg. Co.

Lighting, Industrial
American Fixture Co.
Benjamin Elect. Mfg. Co.
General Electric Co.
Morse Co., Frank W.
Natl. Screw & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Lightning Arresters
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Line Material
Electric Service Supplies Co.
General Electric Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Magnetic Separators
Electric Controller & Mfg. Co.

Magnets
Cutler-Hammer Mfg. Co.

Mallets, Composition
Miller Rubber Co. of N. Y.

Material Handling Equipment
Link-Belt Co.
Weller Mfg. Co.

Metal Stampings
American Pulley Co.

Meters
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.

Meter Testers
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Mica Under Cutting Machines
Hullhorst Micro Tool Co.

Molding, Metal
National Metal Molding Co.

Motors
Allis, The Louis Co.
Allis-Chalmers Mfg. Co.
Baldor Electric Co.
Burke Electric Co.
Century Electric Co.
Chandeysson Electric Co.
Crocker-Wheeler Co.
Electro-Dynamic Co.
General Electric Co.
Hertner Electric Co.
Jeannin Electric Co.
Lincoln Electric Co.
Marble-Card Electric Co.
Master Electric Co.
Natl. Screw & Mfg. Co.
Reliance Electric & Eng. Co.
Star Electric Motor Co.
Sturtevant Co., B. F.
Valley Electric Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Motor Generators
Allis, The Louis Co.
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Crocker-Wheeler Co.
Hertner Electric Co.
Reliance Elec. & Engr. Co.
Westinghouse Elec. & Mfg. Co.

Motor Generator Chargers
Ohio Electric & Controller Co.

Oil Cups
Gits Brothers Mfg. Co.

Oil Gages
Gits Brothers Mfg. Co.

Outlets
American Wiremold Co.

Ovens, Electric
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Overhead Layout Anchorage
Midwest Steel & Supply Co.

Panel Boards
Adam Electric Co., Frank
Benjamin Elect. Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Panel Board Fittings
Chicago Fuse Mfg. Co.

Panels, Switchboard
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Pinions
Foote Bros., Gear and Machine Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 92.

Pipe Benders
Appleton Electric Co.

Plugs
General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Westinghouse Elec. & Mfg. Co.
Attachment
Hubbell, Inc., Harvey

Potentiometers
Biddle, James G.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Power Transmission Appliances
Allis-Chalmers Mfg. Co.
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Lewellen Mfg. Co.
Link-Belt Co.
Nuttall Co., R. D.
Reeves Pulley Co.
Weller Mfg. Co.

Projectors, Floodlighting
Electric Service Supplies Co.
Westinghouse Elec. & Mfg. Co.

Protective Devices
Condit Elec. Mfg. Co.
General Elec. Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Pulleys
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Link-Belt Co.
Reeves Pulley Co.
Smith, Winfield H.

Pulling Tools
Premier Electric Co.

Pull Sockets
Hubbell, Inc., Harvey

Pumps
Centrifugal
Allis-Chalmers Mfg. Co.
Reciprocating
Allis-Chalmers Mfg. Co.

Racks, Machine
Foote Bros. Gear and Mach. Co.

Recorders, Temperature & Pressure
Taylor Instrument Co.

Rectifiers
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Reels, Extension
Appleton Electric Co.

Reflector Hangers
Safety Disconnecting
Thompson Electric Co.

Reflectors
Hubbell, Inc., Harvey
Thompson Electric Co.
Westinghouse Elec. & Mfg. Co.

Regulators
Induction Voltage
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Speed
Cutler-Hammer Mfg. Co.
Industrial Controller Co.
Monitor Controller Co.
Temperature and Pressure
Electric Controller & Mfg. Co.
Taylor Instrument Co.

Relays, Overload
Allen-Bradley Co.

Repair Data
McGraw-Hill Book Co., Inc.

Resistance Units
General Electric Co.
Monitor Controller Co.
Westinghouse Elec. & Mfg. Co.

Rheostats
Allen-Bradley Co.
Biddle, J. G.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Rivets
Hubbell, Inc., Harvey

Rosettes
Hubbell, Inc., Harvey
National Metal Molding Co.

Sanders
Nichols-Lintern Co., The

Schools
Ft. Wayne Correspondence School

Screws, Machine
Hubbell, Inc., Harvey

Searchlights
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Second-Hand Apparatus
(See Searchlight Section)
Gregory Electric Co.

Shapes, Pressed Steel
American Pulley Co.

Signals
Indicating
Nichols-Lintern Co., The
Industrial
Benjamin Elect. Mfg. Co.

Silent Chain Drives
Link-Belt Co.

Slot Cleaning Tools, Commutator
Martindale Electric Co.

Slotters, Commutator
Green Equipment Corp.
Hullhorst Micro Tool Co.
Martindale Electric Co.

Sockets and Receptacles
General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Westinghouse Elec. & Mfg. Co.

Solder
Allen Co., L. B.
Westinghouse Elec. & Mfg. Co.

Soldering Compounds
Allen Co., L. B.

Space Heaters
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Wiegand Co., Edwin L.

Speed Reducers
Falk Corp.
Foote Bros. Gear & Mach. Co.

Starters, Motor
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Monitor Controller Co.
Square D Co.
Sundh Electric Co.
Union Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Stones, Commutator
Green Equipment Corp.
Martindale Electric Co.

Stop Signals
Nichols-Lintern Co., The

Strip Heaters
Westinghouse Elec. & Mfg. Co.
Wiegand Co., Edwin L.

Stringers, Steel
Midwest Steel & Supply Co.

Substations, Outdoor
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Supplies, Electrical
Flower, D. B.
Green Equipment Corp.
General Electric Co.
Hubbell, Inc., Harvey
Weeks, Arthur B.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

(Continued on page 90)

Keep Your Motors Running

Prevent Burnouts and Costly Shutdowns

THE new Cutler-Hammer "X" Starters keep the motors running—prevent production delays.

Aside from their long life construction—the *thermal* overload protection allows the motor that is thrown across the line sufficient excess current to accelerate properly. A rise in current does not necessarily cause the motor to be disconnected.

But, if the overload during starting or when running maintains long enough to cause serious overheating of the motor windings—then (before damage occurs) the motor will be disconnected.

Two safeguards against delays

First—the motor is not unnecessarily and frequently cut off from the line.

Second—burned-out motor windings are prevented—thus eliminating replacement of motor and expense of re-winding.

A few in stock will take care of the requirements for a wide range of motors from ¼ hp. up to 7½, 10 and 15 hp. depending upon the voltage and type of motor. By simply using the Thermal Cutout of proper rating for the 9585 Starter, or the proper relay heater coil for the 9586, the one starter is suitable for use with motors of various sizes. Let us mail you our new publication No. C-25.

New C-H Thermal Overload Relay has ideal protective characteristics. Nothing to replace after tripping—simply press the reset button. Adjustable to individual motor loads, giving exceptionally wide application.

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"What & Where to Buy"

(Continued from page 88)

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Department (construction, installation, repair, etc.)_____

Principal product of company_____

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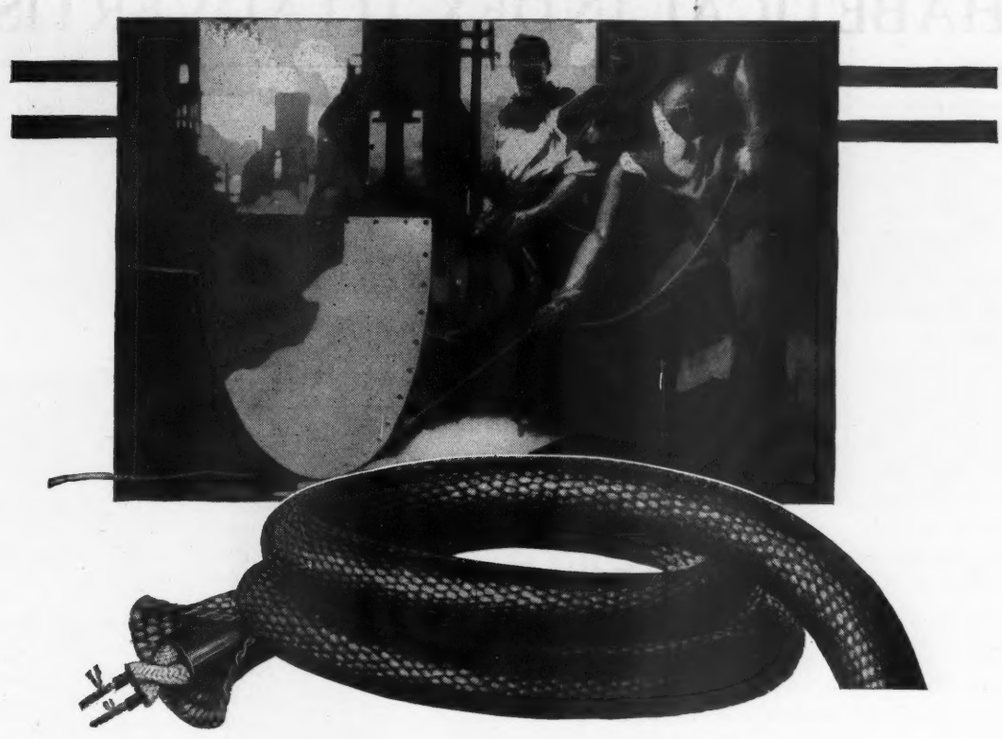

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Every part of DURACORD has ample strength to stand the hard knocks of everyday service.

Its conductors are composed of fine strands of pure copper—they help make DURACORD extremely flexible.

DURACORD

REG. U.S. PAT. OFF.

The DURACORD cover is woven parallel to the conductors. It resists jerks and pulls and prevents the copper stretching and breaking inside the cord.

Check up with your maintenance man on the number of breakdowns caused by conductors stretching. You'll find they form a large portion of your cord troubles.

If DURACORD did nothing but rid your plant of this trouble, you would be justified in putting it on the job.

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TUBULAR WOVEN FABRIC CO.

PAWTUCKET, R. I.

Makers of

DURADUCT—Non-metallic Conduit
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ALPHABETICAL INDEX TO ADVERTISERS

Adam Electric Co., Frank....66
Allen Co., L. B., Inc....54
Allen-Bradley Co....15
Allis-Chalmers Mfg. Co....2nd Cover
Allis Co., The Louis....29, 30
American Circular Loom Co....76
American Enameled Magnet Wire Co....78
American Fixture Co....63
American High Speed Chain Co....46
American Insulated Wire & Cable Co....78
American Pulley Co....49
American Resistor Co....27
American Steel & Wire Co....13
American Transformer Co....85
American Wiremold Co....80
Anchor Webbing Co....76
Appleton Electric Co....11
Armature Coil Equipment Co....78
Audel & Co., Theo....84

Baldor Electric Co....56
Baylis Company, The....42
Belden Mfg. Co....77
Biddle, James G....69
Boxill-Bruel Carbon Co....9
Burke Electric Co....56
Bussmann Mfg. Co....23

Calebaugh Self-Lubricating Carbon Co.40
Campbell Mfg. Co....44
Carbon Engineering Co....40
Century Electric Co....57
Century Electrical Co....61
Chandeysson Electric Co....56
Chicago Pneumatic Tool Co....71-72
Chicago Rawhide Mfg. Co....39
Chittenden, Charles L....84
Clements Mfg. Co....60
Condit Electrical Mfg. Corp....6
Corliss Carbon Co....42
Crocker-Wheeler Co....61
Cutler-Hammer Mfg. Co....21, 89
Cutter Co., The....3rd Cover

Dodge Mfg. Corp....19-20
Dolph Co., The John....58
Dossert & Co....76

Electric Blower Co....60
Electric Controller & Mfg. Co....28
Electric Service Supplies Co....58
Electro-Dynamic Co....31
Elwell-Parker Electric Co....54
Equipment Wanted....84

Fafnir Bearing Co., The....43
Falk Corp., The....17
Ferer & Sons, Aaron....70
Flower, D. B....39
Foote Bros. Gear & Mach. Co....44
For Sale Ads....84
Ft. Wayne Correspondence School....84

General Electric Co....8, 25, 52-53, 87
Gits Brothers Mfg. Co....58
Green Equipment Corp....69
Gregory Electric Co....84

Hertner Electric Co....60
Hohman & Hill, Inc....42
Hubbell, Inc., Harvey....12
Hullhorst Micro Tool Co., The....62
Hyatt Roller Bearing Co....7

Impervious Varnish Co....67
Indiana Rubber & Insulated Wire Co....79
Industrial Controller Co....Back Cover
Industrial Engineer....74
Irvington Varnish Co....81

Jeandron, W. J....58
Jeannin Electric Co....61
Johns-Pratt Co....18

Klein & Sons, Mathias....67
Koch & Co., Paul W....39

Leather Belting Exchange....46
Lewellen Mfg. Co....50
Lincoln Electric Co....4-5
Link-Belt Co....51

Marble-Card Electric Co., The....58
Maring Wire Co....78
Martindale Electric Co....82
Master Electric Co....56
McGraw-Hill Book Co....48, 55, 68
McGraw-Hill Co., Inc....64-65
Midwest Steel & Supply Co....50
Miller, Rubber Co. of N. Y....39
Monitor Controller Co....24
Morganite Brush Co., Inc....68
Morse Co., Frank W....69
Mutual Fdry. & Mach. Co....54

National Carbon Co....41
National Electric Light Association....33
National Metal Molding Co....14
National Screw & Mfg. Co....63
Nichols-Lintern Co., The....66
Norma-Hoffmann Bearings Corp....48
Nuttall Co., R. D....82

Ohio Electric & Controller Co....40
Okonite Co., The....16
Okonite-Callender Cable Co., Inc., The..16

Phillips Wire Co....78
Positions Vacant....84
Positions Wanted....84
Premier Electric Co....40

Reeves Pulley Co....49
Reliance Electric & Engineering Co....59
Roller-Smith Co....62
Rome Wire Co....22
Russell Mfg. Co....62

Schwarze Electric Co....40
Searchlight Section....84
Simplex Wire & Cable Co....75
Smith & Serrell....45
Smith, Winfield H....45
Square D. Co....26
Standard Conveyor Co....47
Star Electric Motor Co....56
Sterling Varnish Co., The....67
Sturtevant Co., B. F....60
Sundh Electric Co....54

Taylor Instrument Co....10
Thompson Electric Co., The....63
Timken Roller Bearing Co., The....Front Cover
Torrington Co., The....45
Trico Fuse Mfg. Co....44
Trumbull Electric Mfg. Co., The....80
Tubular Woven Fabric Co....91

Union Electric Mfg. Co....44
U. S. Rubber Co....32

Valley Electric Co....61

Weeks, Arthur B....40
Weller Mfg. Co....45
Western Electric Co....83
Westinghouse Elec. & Mfg. Co....34-38
Weston Electrical Instrument Corp....70
Wiegand Co., Edwin L....73
Worcester Blaech & Dye Works Co....78

York Insulated Wire Co. of G. E. Co....76

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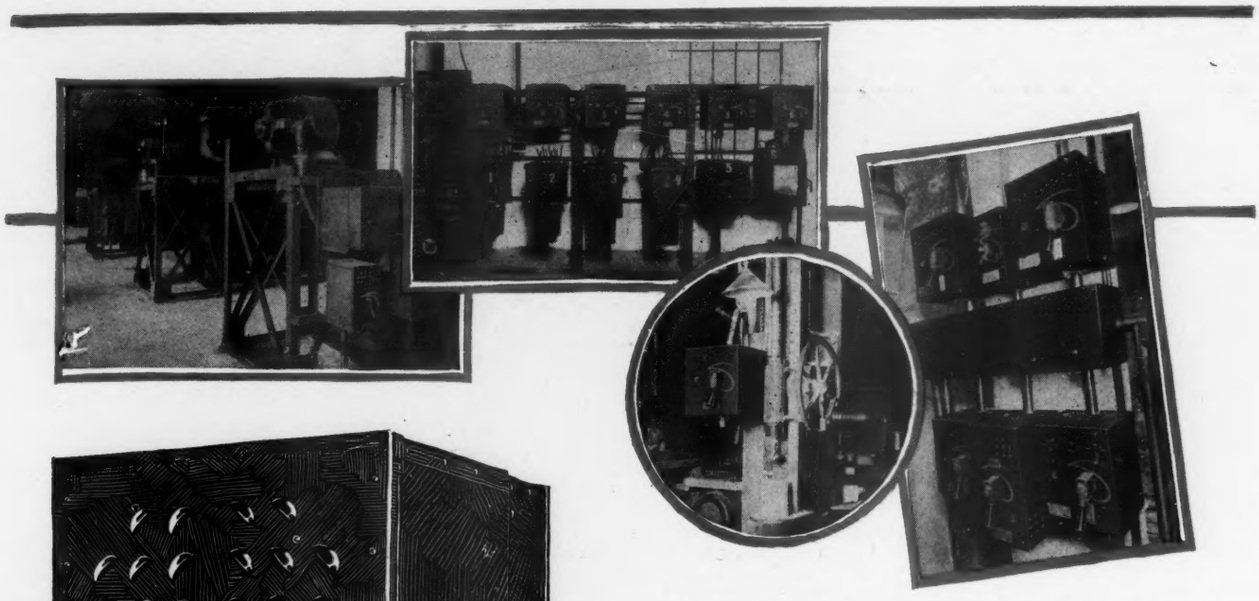

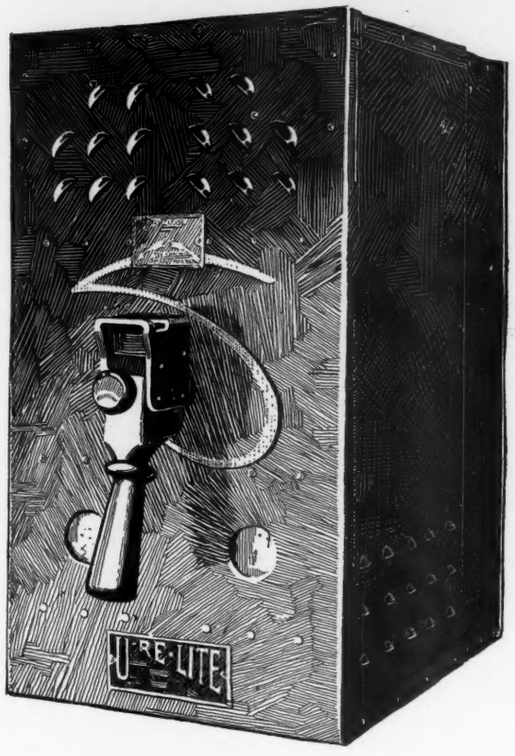

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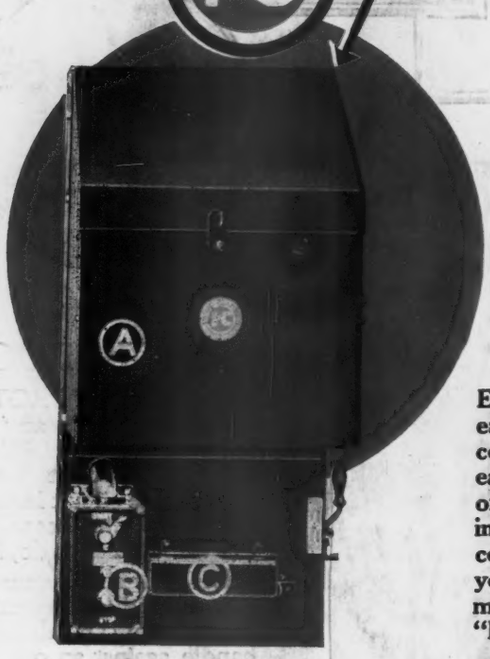

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Each part is a masterpiece, each simple in design and construction, each capable of easy installation, each part of each section standard and interchangeable—and such a compact unit! Let us tell you of the big Detroit automobile plants equipped with "IC" Automatics.

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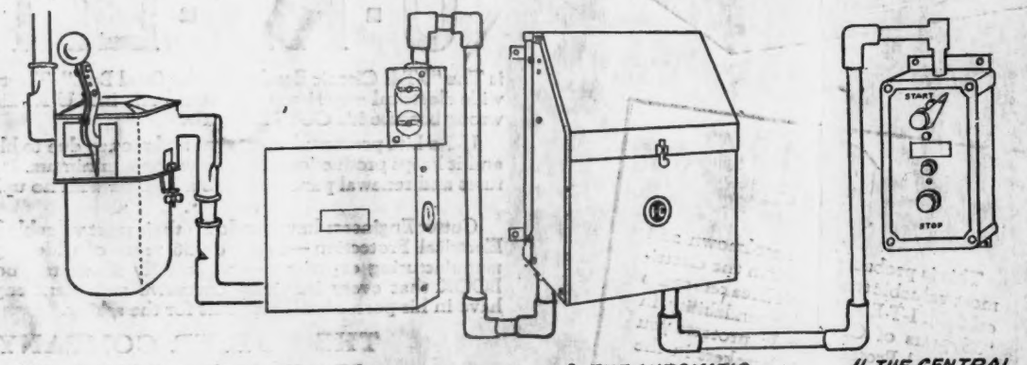

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Milwaukee, Wisconsin

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